New England Railroad Club

January 12, 1904.

SUBJECTS FOR DISCUSSION:

Piston Valves vs. Slide Valves.

Paper by B. P. FLORY.

The Piston Valve as Applied to Locomotives.

Paper by Mr. J. M. FITZGERALD.

E. L. JANES, SECRETARY, SOUTH TERMINAL STATION, BOSTON, MASS.

INDEX TO ADVERTISERS

NEW ENGLAND RAILROAD CLUB.

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The regular meetings of this Club are held at Pierce Hall, Copley Square, corner of Dartmouth Street and Huntington Avenue, Boston, on second Tuesday of each month, excepting June, July, August and September.

NEW ENGLAND RAILROAD CLUB

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E. L. JANES, SECRETARY, SOUTH TERMINAL STATION, BOSTON, MASS.

$1.00 A YEAR. *Boston, January 12, 1904.* 15C. A COPY.

A REGULAR MEETING of the New England Railroad Club was held at Pierce Hall, Copley Square, Boston, on Tuesday evening, January 12, 1904, at 8 P.M., President F. W. Dean in the chair.

The following members registered :—

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Rhine, A. K.	Spinney, E. D.	Thayer, Albert
Robertson, W. J.	Swett, G. W.	Webster, George S.
Robinson, J. B.	Smith, C. B.	Whitney, F. H.
Rice, Edmund	Turner, I.	White, A. M.
	Towle, J. M.	

THE PRESIDENT: The minutes of the last meeting have been printed, as you have doubtless seen, and they will stand approved unless there is objection to them.

Have you any Reports of Committees?

THE SECRETARY: No reports, Mr. President.

THE PRESIDENT: There are no reports of committees. Under the head of Unfinished Business, it might be well to state that the corrected proof of Mr. Parke's paper has not been received from him, and, therefore, the November Proceedings have not appeared. There have been various difficulties. I understand from the Secretary that the printer had to get some Greek letters cast by the type-foundry to use in the publication.

You have all received notification, I suppose, of the ladies' night which is to take place on the 26th instant. Mr. Barbey is here, and he will be glad to sell as many tickets as possible and receive as much money as possible therefor. It has not been stated in the notices, nor on the tickets, that a collation similar to what we have at the end of each meeting will be served, and that for it there will be no extra charge.

The Secretary will announce the new members that were voted in tonight.

THE SECRETARY: The Executive Committee has accepted the applications for membership of the following gentlemen: Mr. Frank B. Archibald, representing Berry Brothers, Ltd., New York City; Mr. Clarence E. Sprague, representing the General Electric Company, Boston; Mr. George Wright Swett, S.B., Massachusetts Institute of Technology, Boston.

THE PRESIDENT: These gentlemen have all been passed upon by the proper committee, and have been voted in by the Executive Committee.

There has been some discussion from time to time in regard

to the initiation fee paid on entering this Club, and also the annual dues. You may possibly remember that the amount of the fee was advanced somewhat a few years ago. It has now been thought best to reduce it in a certain sense, and for that reason the Executive Committee has framed a new Article for the Constitution, which, in accordance with our rules, has to be read before the Club and then voted upon at the following meeting. Will you please read the new Article?

THE SECRETARY: The recommendation of the Executive Committee to the Club relating to this Article is as follows: —

The initiation fee shall be $5.00, which shall include the dues until the next annual meeting, and the annual dues thereafter shall be $2.00 a year, payable in advance on the second Tuesday in March of each year, of which $1 shall be in payment of one year's subscription for the printed Proceedings of the Club at the published price. Members whose dues remain unpaid at the regular meeting in May following, shall forfeit membership and all rights and privileges of the Club. Nothing in the provision of this Article shall prevent delinquent members from making new application; and said application shall be subject to the same action as in the case of application of new members, with the exception of the initiation fee.

THE PRESIDENT: As I understand it, this new Article will be read again at the next meeting, and will then be voted upon by the members.

THE SECRETARY: Yes, sir.

THE PRESIDENT: Is there any other New Business?

THE SECRETARY: I know of none.

THE PRESIDENT: I think there is no other routine business to be transacted, unless some member has something to propose. If not, we will proceed to the papers of the evening.

MR. GRAHAM: Mr. President, you say $5.00 initiation and $2.00 dues. What is the change, then?

THE SECRETARY: The initiation fee shall be $5, which shall include the dues until the next annual meeting.

MR. GRAHAM: Thank you.

THE PRESIDENT: We will now pass to the papers of the evening, viz., Piston Valves *vs.* Slide Valves. The first paper will be by Mr. P. B. Flory, who is mechanical engineer of the Lehigh Valley Railroad. I take pleasure in introducing Mr. Flory.

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PISTON VALVES VERSUS SLIDE VALVES.

BY

B. P. FLORY.

Mr. President and members of the New England Railroad Club:—

In taking up the subject of Piston Valves versus Slide Valves, it has been found rather difficult to get any exact information on the comparative advantages of each. A study of all the literature written on this subject discloses the fact that most of what has been written is a result of personal opinion only. Few tests have been made, and they have not been made on the more recent types of balanced slide valves and piston valves.

Piston valves in use on simple engines may be divided into three classes — (first) the solid piston with internal admission and external exhaust; (second) the hollow piston with internal admission and external exhaust; (third) the solid piston with external admission and internal exhaust.

The internal type of piston valves with the usual style of packing rings permits steam to enter below the rings, forcing them against the valve bushing with full friction of steam pressure per square inch of ring surface. The valves of this type, therefore, are not perfectly balanced.

The solid form with internal admission is also objected to on account of not permitting the exhaust to circulate freely, except in a round-about way through the cylinder saddle and back to the opposite end of the valve chamber. In a paper before the Richmond Railroad Club, Mr. Haughton states that on some tests made with full throttle the indicator card showed a pressure of 54 pounds on the end of the valve exhausting and but 2½ pounds on the opposite end of the valve at the same moment. This load is applied very suddenly, and, therefore, takes up all the lost motion in the valve gear from the valve to the eccentrics with a sudden shock.

Some piston valves have been used without packing rings, and though some roads claim that they have given good service, yet it does not seem possible to the writer to make a

valve that will expand and contract in the same degree as the valve chamber bushing. If the valve moves freely there must be an appreciable amount of steam lost, and as the valve cannot be made too tight it must leak. With piston valves it is also necessary to provide some means for relieving the cylinder from excessive pressure of water or of air in case the engine is drifting. To accomplish this relief valves have been used in most designs. When relief valves are used they have to be tightened down to withstand a pressure greater than that in the steam chest; otherwise they will leak steam. Usually they are tightened down too much, and thus destroy their usefulness and prevent the relief of compression when the engine is drifting.

The Southern Pacific have used a circulating pipe that seems to have solved some of the difficulties due to relief valves. Quoting from their letter as given in the Proceedings of the American Railway Master Mechanics' Association of this year, they say: "The circulating pipe sent herewith shows an arrangement that not only takes care of compression and surplus moisture, but, as will be seen by reference to the print, will also take care of the temperature of the cylinders while drifting. It takes care of the partial vacuum that is responsible for incandescent hot gases of smoke box entering cylinders through the exhaust nozzle. The piston valves in constant use for the past two years with the circulating device are in perfect order today with little, if any, indication of wear. The cost of caring for the piston valves during this time has been nothing more than that of bushing the front end horn or guide when engines were shopped."

One of the most interesting types of piston valves with internal admission is the American semi-plug piston valve. As only two of these valves are in use at the present time, I will give a description of them:

The inner sides of the two snap rings are beveled. The outer sides of the snap rings are straight and fit against the straight walls of the valve spool. Against the beveled sides of the snap rings, solid, uncut, non-expansible wall rings fit. Their inner sides are beveled at a greater degree of angle than their outer sides which fit the snap rings. In between

the two walls is placed a central double-tapered snap ring. This ring is properly lapped and is put under tension, thus holding the wall rings apart, putting a slight grip on the snap rings laterally.

The action of the rings is as follows:—When steam is admitted to the steam chest it passes through the openings in the spool to the space beneath all of the rings, and acts simultaneously upon the snap rings and the central wedge ring. The snap rings are thus expanded against the casing at the same instant that the central wedge ring grips them there, and they are prevented from further expansion. This makes a valve that expands and takes care of itself, not only for difference in contraction and expansion, but also for wear. The rings are so lapped that they are steam tight from all directions, and, by the bevel lap joints, unbroken steam and exhaust lines are secured at the edge of the ring.

One of these valves has been in use on the Buffalo & Susquehanna Railroad since March, 1901, and during all that time the valves have never been taken out for repairs excepting to apply packing to the valve stem. This valve is running without relief valves, by pass valves or pop valves on the cylinders or steam chest and drifts very smoothly. This engine has been in constant service since the valves were put in, excepting having a general overhauling which took about 27 days, and the valves required no attention whatever and gave no appearance of wear.

Some of the other disadvantages of piston valves are excessive clearance and liability of packing rings and edges of grooves in the spool breaking. These are so well known that it is not necessary to dwell on them here.

It has also been the opinion of most roads using piston valves that greater care has to be taken in refitting and repairing them than with slide valves.

Lubrication of piston valves is also a difficult thing to take care of if the engine has to do much drifting. When an engine has drifted for some time the walls become chilled, making it almost impossible to get oil to the valve. This, of course, tends to make the packing rings and valve chamber bushing wear.

The chief advantages claimed for the piston valve are usually that it is better balanced, and that there is less wear and tear on the motion work than with the slide valve.

While the piston valve may be better balanced than most types of slide valves, yet the American high-pressure balanced valve is probably better or at least is as well balanced as any type of piston valve. I will say more about this valve shortly.

Now, taking up the slide valve, we find that ever since its introduction various attempts have been made to balance the valve, thus reducing the pressure of the steam on the valve seat, which causes excessive friction and wear.

In regard to the amount of friction of slide valves, experiments made by Thurston on a small stationary engine showed that the friction of an unbalanced slide valve and its gearing constituted 25 per cent. of the entire friction of the engine, while with a balanced slide valve only one fifth to one tenth as much.

The principal forms of balanced slide valves in use today are the Richardson, American and Allen.

The Richardson valve is balanced usually about 55 per cent. of its area, and depends for its balance on planed pieces held to the balance plate by flat springs until the steam pressure seats them. One of the principal claims for this valve is that no part of the balance device passes over or rubs on the path of any other piece, thus insuring a tight joint at various valve travels.

The American double balance valve — that is, with two rings — has about 65 per cent. of its area balanced.

In the Allen valve the seat is shortened, and a supplementary port is cast through the valve. In full gear this nearly doubles the speed of opening, but as the port is wide open with a plain slide valve, little benefit results from this. However, when working at from one quarter to one half cut off, the speed of the port opening and closing is not only doubled, but the port opening itself is in most cases doubled

The tests made by the Master Mechanics' Association in 1896 show that the mean effective pressure is about 20 per cent. greater with the Allen balanced valve than with the plain slide valve,— that is, at running positions. Of course

this does not mean an economy of 20 per cent. in fuel, because as more steam is admitted to the cylinder more fuel must be used. It does mean, however, that with a given engine much more power can be developed with an Allen valve than with the plain slide valve. The Allen valve is very satisfactory with high speeds and early cut offs, and as this valve is used almost exclusively in passenger service it does very good work.

Referring again to the friction of slide valves and to the Master Mechanics' Association Report of 1896, the tests made showed as follows: —

I. H. P. in moving one valve —	plain valve	.860	10 miles per hour 1st notch.
" " " " "	Richardson	.334	
" " " " "	American	.362	
" " " " "	plain valve	1.868	20 miles per hour 1st notch.
" " " " "	Richardson	.784	
" " " " "	American	1.000	
" " " " "	plain valve	.585	10 miles per hour 14th notch.
" " " " "	Richardson	.206	
" " " " "	American	.181	

We see from these tests that the American double balance valve and Richardson valve absorb about the same amount of work under the same conditions.

Tests made by the Chicago, Burlington & Quincy Railroad in 1899 for the friction on piston valves, show with an engine having a steam pressure of 145 pounds that the pull on the valve (in pounds) was 415 pounds at 83 revolutions per minute; while with another engine having a steam pressure of 200 pounds the pull was 120 pounds.

Comparing these with the tests of the Master Mechanics, Association at the same speed we have: —

Plain slide valve	pull	1,260	pounds.
Balanced slide valve	"	480	"
Piston valve (engine 145 pounds steam) . .	"	415	"
Piston valve (engine 200 pounds steam) . .	"	120	"

The tests made by the Chicago, Burlington & Quincy Railroad on friction of hollow and solid piston valves also show a decrease of friction for the solid valve.

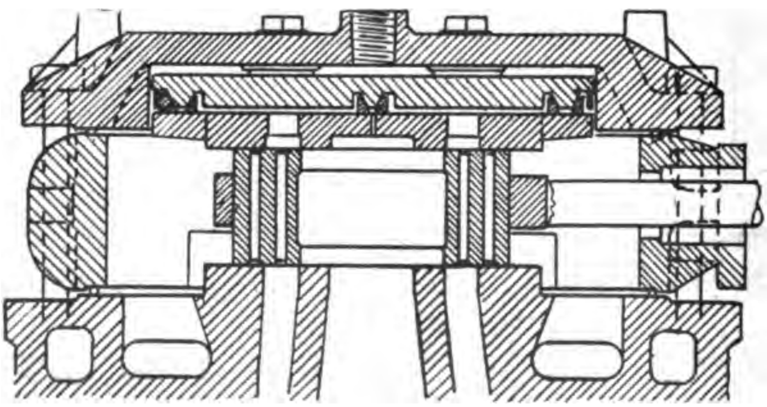
From tests made on the Lake Shore & Michigan Southern Road in 1902 for water consumption between similar engines,

one equipped with the Richardson balanced valve and the other with a piston valve, an average of 20 tests gave water per ton mile per hour 4.16 pounds for the piston-valve engine and 4.3 pounds for the slide-valve engine. This, however, is offset by the fact that the piston-valve engine used .872 pounds coal per ton mile per hour, while the slide-valve engine used only .845 pounds coal per ton mile per hour.

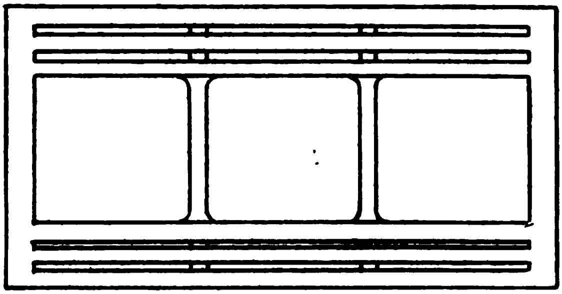
The tests made on the Delaware & Hudson Road with a piston-valve engine that had 84.3 square feet of heating surface, 5 square feet of grate surface and 10 pounds more steam pressure than a slide-valve engine, showed the slide-valve engine to use about 1.8 per cent. more water than the piston-valve engine.

These two tests are about the only ones we have any record of as regards water consumption, and the differences are so slight it is hard to say which class of valves showed up better.

Now, coming to the latest type of the American high-pressure balanced valve,—this valve is so perfectly balanced that friction is practically eliminated. The balanced area is also changeable, and this change of balance corresponds with the changed conditions of the valve on its seat at the different points of its travel. This, therefore, makes a perfectly balanced valve in all positions. Another great advantage in using this valve is that a very large exhaust opening can be secured.



CROSS SECTION.



PLAN OF VALVE.

WILSON HIGH-PRESSURE BALANCED VALVE.

While there is no doubt in the mind of the writer that this valve is the best one we have for steam efficiency and for balance, yet it remains to be seen whether it will stand the hard service that will be given it on some roads.

On some roads it has given very good satisfaction, while on others some trouble has been experienced by having the rings break. While this has been partly remedied by making the small rings of steel or brass instead of cast-iron, the fact remains that something more will have to be done to this valve to enable it to stand severe service.

No tests have been made as yet between this type of valve and the piston valve, but I believe there is a committee appointed by the Master Mechanics' Association to do that this year. The outcome of these tests will then give us some reliable data on which to base our future designs.

Summing up, then, the principal advantages of the piston valve versus slide valve are — better balance, less wear and tear on the valve motion work. And the disadvantages are — wear of packing rings; breaking of packing rings and edges of grooves in spool; liability to blow; increased clearance; difficulty of lubrication; more skilled labor to care for valves; difficulty of keeping relief valves in order.

Of course the advantage of better balance will not hold in the case of the piston valve versus the American high-pressure balance valve.

The President: I think, perhaps, it will be better to have the next paper before we begin the discussion, and will therefore ask Mr. J. M. FitzGerald of the Boston & Albany Railroad to read what he has prepared. I take pleasure in introducing Mr. FitzGerald.

THE PISTON VALVE AS APPLIED TO LOCOMOTIVES.

Paper by Mr. J. M. FitzGerald.

Mr. President and Gentlemen:—

The American Master Mechanics' Association have taken up the subject of the Piston Valve as applied to locomotives, and in their convention last June listened to an extensive report on the merits and defects of this valve, thus showing the importance of this subject to the railroad world.

Piston valves have been, and are, extensively used in marine practice, but marine and railroad conditions and requirements are so different that no comparison in the two practices can properly be made.

When it was first considered necessary to use high pressure steam, that is, 190 pounds and over, it was found that the ordinary slide valve could not be conveniently and easily balanced for this pressure. In fact, under these high pressures with the large sized engines, difficulty of handling and the increased cost of maintenance of valve and valve rigging practically prohibited the use of the slide valve. In this time of need the piston valve was brought forth. This valve is primarily a high pressure valve, that is, it gives the best satisfaction under high steam pressure. This is due to the fact that this valve is more nearly perfectly balanced. It is principally on this account that it is being so extensively used and not because of its economy, although the Lake Shore & Michigan Southern Railroad claims to show a saving of 5 per cent. over the slide valve, due to decrease of back pressure and compression.

These valves have been used extensively in some forms of

compound engines but in these cases the valve was used more because of its adaptation to certain requirements of steam distribution than any other general merit. Compound engines, however, are outside the scope of this paper, and all statements made are as regards the piston valve applied to simple engines.

If we take a longitudinal vertical section of the ordinary "D" slide valve and consider it rotated through 360 degrees about the top of the valve as an axis we develop a piston valve. Four (4) types have been developed and used more or less. There is the solid external admission type, which is the direct development of the slide valve. Directly developed from this is the hollow external admission valve. Both have the same action as the slide valve, and can be adapted to the ordinary arrangement of valve gear. The great objection of these types is that they require a separate branch steam pipe to each end of the valve chamber, thus bringing the live steam in direct contact with the exposed parts of the saddle casting, with a large loss due to condensation. The other two types are the solid internal admission and the hollow internal admission. These require a direct valve motion, whereas the slide valve has an indirect motion. In these last two the steam is taken at the centre and exhausted at the ends, and the loss from condensation is less, because the exhaust steam is in contact with the exposed parts rather than the live steam, and further, it is exhaust steam which is in contact with the stem packing, and thus less attention is required for packing. Of course there is the objection that the live steam is entirely jacketed by the cooler exhaust steam.

Experiments have been made with the third type. This has the internal admission, but is without the hollow centre, thereby preventing the exhaust at either end from circulating back and forth, except in a roundabout way through the cylinder saddle and back to the opposite end of the valve chamber. This takes time to do, and, therefore, causes an unequal pressure on the opposite end of the valve, which is greatest with the following combined conditions : slow speed, full throttle, maximum cut off, and at the moment exhaust opening occurs.

The extent of this unbalanced pressure does not seem to be generally appreciated.

Indicator diagrams, however, illustrate the degree of unbalance as well as the suddenness of its occurrence. They were taken from a modern consolidation freight engine equipped with piston valves of this type.

Diagrams from the cylinder and valve chamber were taken simultaneously with two indicators, so that the conditions of steam distribution in the cylinder and the exhaust chamber might be known and compared.

The card illustrating the worst condition shows a pressure of 54 pounds on the end of the valve exhausting, and but 22 1-2 pounds at the opposite end at the same moment. The diameter of the valve being 11 inches, the unbalanced load on one end due to this pressure amounts to 4,960 pounds. The suddenness with which this load is applied is indicated by the almost perpendicular rise shown on the diagram near the end. The unbalanced load on the end of the valve acts in the same direction in which it is moving and takes up all the lost motion in valve gear from the valve to the eccentrics with a sudden shock, the extent of which depends on the degree of lost motion, but which is apparent on any engine equipped with this form of piston valve. It is needless to dwell on the fact that such shocks must be detrimental to the valve gear throughout.

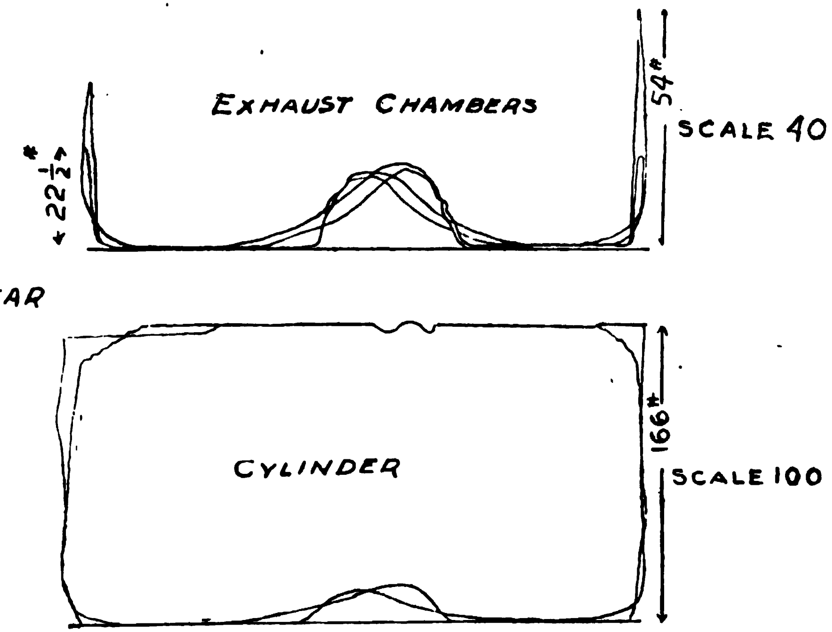
Cards taken at a somewhat faster speed than the above show how this effect diminishes as the terminal pressure in the cylinder becomes less, due to shorter cut-off.

Despite these cards, which tend to show this type defective, the L. S. & M. S. R.R. report 21 per cent. of their equipment equipped with this type, and further, that it gives satisfaction with the exception that it wears the main driving box out faster. To my mind this very defect proves the truth of the statements just previously read. As far as I can discover, this road uses no by-pass valve or other device to permit circulation of exhaust from one end of valve chamber to other, and therefore, this immense back pressure just shown in this type exerts its full power on valve gear and connections and that means eccentrics and main axle and thus the fast wear of main driving-box.

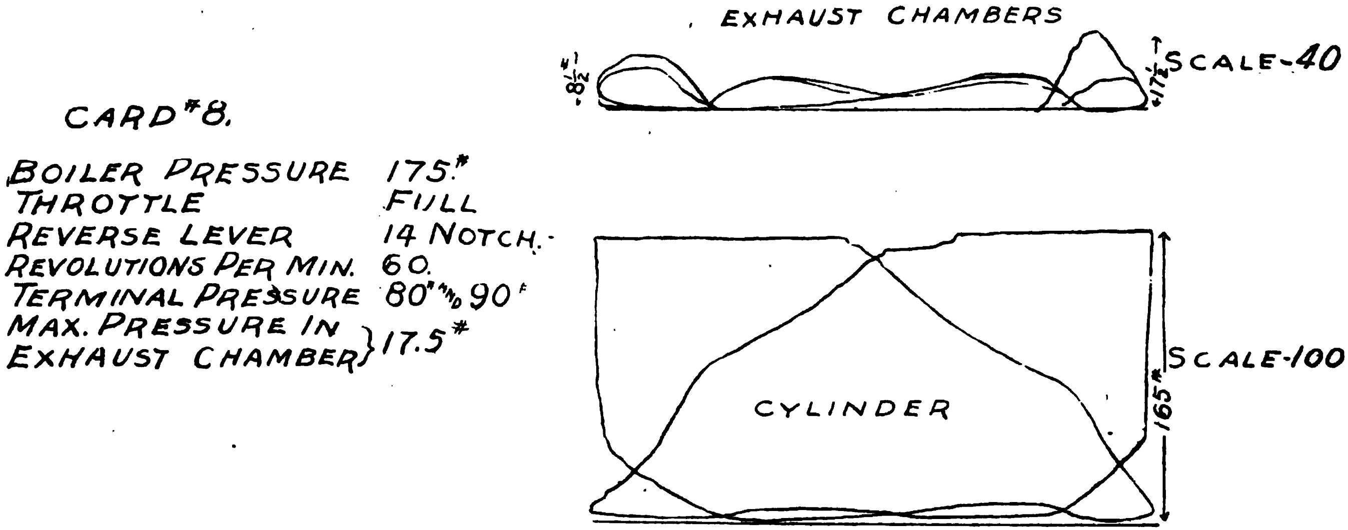
Unless otherwise stated, the rest of this article will refer to

CARD #6

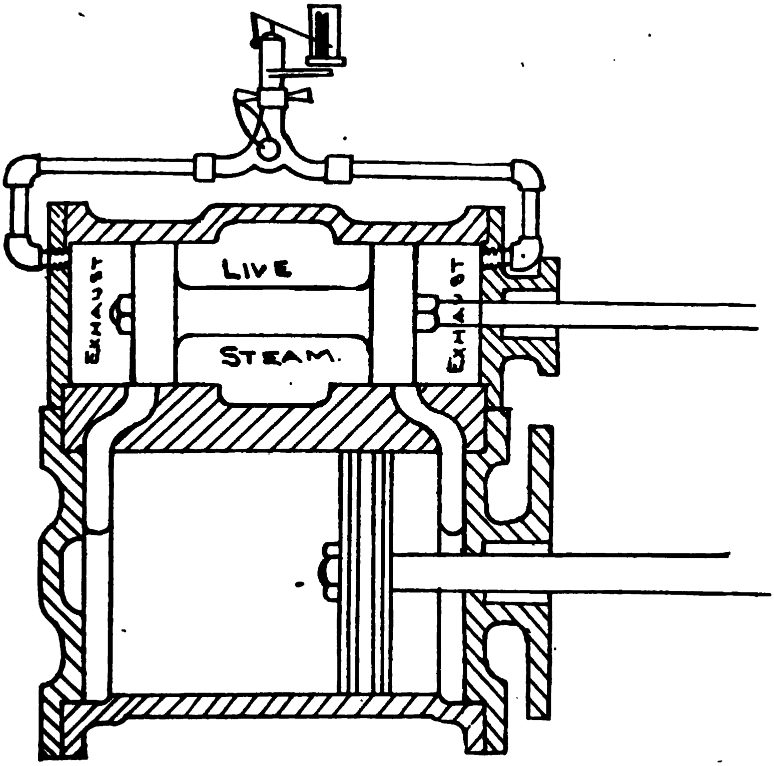
BOILER PRESSURE 185
THROTTLE FULL
REVERSE LEVER FULL GEAR
REVOLUTIONS PER MIN. 33
TERMINAL PRESSURE 145#
MAX. PRESSURE IN EXHAUST CHAMBER } 54#



INDICATOR CARD FROM SOLID INTERNAL ADMISSION PISTON VALVE.



INDICATOR CARD FROM SOLID INTERNAL-ADMISSION PISTON VALVE

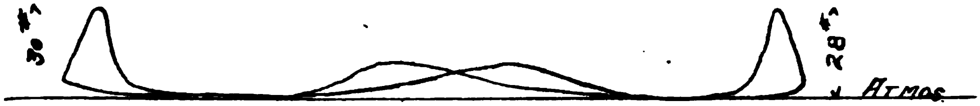


METHOD OF PIPING STEAM CHEST FOR INDICATING.

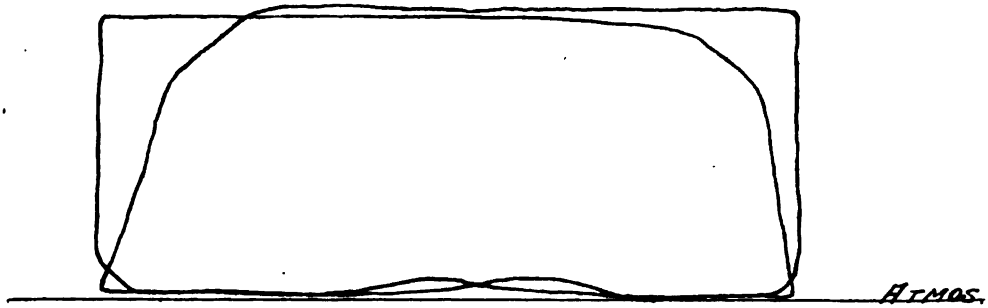
the hollow internal admission type of piston valve, which is the form in most common use and the one giving the best general satisfaction. In this type the exhaust steam can flow from end to end of valve chamber through the hollow valve, thus the objection of the foregoing type is eliminated to a great extent.

Cards were taken of a piston valve of this type on a fast passenger engine of the Central Atlantic type. The following, which are the average cards obtained under the conditions stated, will serve to compare with the cards from the solid internal admission valve shown above.

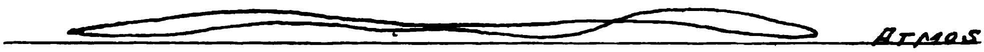
One of the merits originally claimed for the piston valve was that the clearance space was much less with this valve than with the ordinary slide valve. The average clearance of the slide valve is about 10 per cent. to 15 per cent. of the piston displacement. It seems few piston valve engines have been



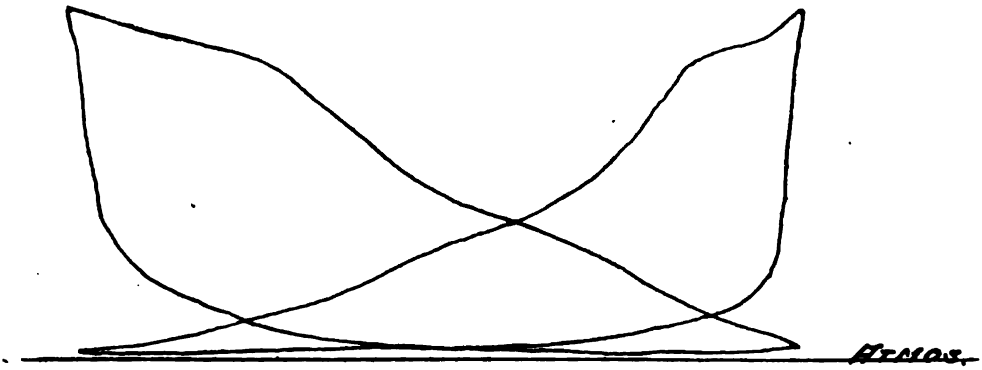
VALVE CARD — STARTING — #1
SPRING — 60#



CYLINDER CARD — STARTING — #1
SPRING — 100#



VALVE CARD #2 175 R.P.M.
SPRING — 60#



CYLINDER CARD #2 175 R.P.M.
SPRING — 100#

CARDS SHOWING ACTION IN STEAM CHEST WHILE WORKING STEAM IN A HOLLOW INTERNAL ADMISSION PISTON VALVE.

CHASE GOAT BRAND CAR PLUSHES Are the Standard.

Eighteen years of constant use by the leading railroads and car-builders of this country has demonstrated their superiority both as to fastness of color, superiority of workmanship, and strength of fabric.

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CAR CURTAINS

Used for eleven years by Leading Railways with unqualified satisfaction. Waterproof, Grease-proof, and Stormproof. Always flexible, easily cleansed. The success of Pantasote has produced imitations which can be detected by applying a lighted match to the coated surface. The imitation will burn fiercely, Pantasote WILL NOT BURN.

EVERY-THING GOES DOWN BEFORE IT.

SAMPLES ON REQUEST.

Pantasote Co.
11 Broadway,
NEW YORK CITY, N.Y.

designed in the last few years that have a clearance exceeding 9 per cent. I have no definite data on the subject but I am inclined from a general study of the matter to say that there is practically as much clearance in the piston valve as in a well-designed slide valve.

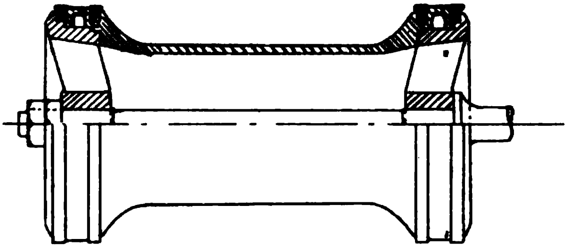
On account of the balancing and friction of the necessarily large heavy slide valve required with high pressure steam used in large engines, ports are placed as close together as possible in order to get the smallest and lightest valve possible. Placing the ports near the center of the cylinder requires long and tortuous steam passages. With the piston valve, however, the valve can be made long and the ports placed near the end of the cylinders, thus giving short, direct steam passages. It must be remembered, however, that the annular space about the port of this valve adds to the clearance.

It is the general practice to have the cylindrical valve chamber bushed with cast iron. One piece bushings have been used quite extensively but more commonly we find two-piece bushings. The latter are easier to place and require less attention in fitting. These bushings are usually shrunk in in the same manner as the ordinary cast iron cylinder bushings, but in many cases they are pressed in.

There is some difference in opinion as to which is the better form of bridging in ports of these bushings, the longitudinal or diagonal. The claim for the latter is that the wear of valve ring is more even and, therefore, less liability of leakages or breaking of rings. The longitudinal bridge is less expensive and gives good satisfaction.

The general form of the valve spool can be seen from the sketch.

The valve ring is a weak point of the piston valve. No experiments seem to have been made with a view to determining the steam loss due to worn rings. It has been shown by shop tests on this point that rings can easily represent a loss of 15 per cent. over steam consumption with rings in first-class condition. It undoubtedly varies, due to several conditions: the type of the ring, the size of the ring, the type of the valve, and the length of period between re-boring of valve chamber bushings and application of new packing rings.



— SKETCH OF PISTON VALVE SPOOL —

Various types of packing rings are in use, as well as rings of the same style varying greatly in their dimensions. The rectangular cast-iron snap rings, together with a cast-iron "L" ring, appears to be used in the majority of cases, while for the rectangular rings about 3-8" x 1-2", and for "L" rings 5-8" x 1-2" seem to be the prevailing sizes. In some few of the valves provided with followers heavier rings are used, and it is questionable if the prevailing practice is not too light rather than too heavy. As regards the various advantages of rectangular and "L" shaped rings it would seem that rectangular rings generally have advantage of strength, longer life, cheaper cost and cheaper maintenance, while to offset this, the "L" ring, especially on high speed engines, gives a very much better port opening, with less wire drawing of steam. The "L" ring naturally has a greater unbalanced surface than the rectangular ring, and it is the experience of one road that it wears both itself and the chamber very much more rapidly than the rectangular ring. As to the efficiency or economy of various types of rings, it would seem from indicator tests that the steam distribution appears as good with one form as with the other. One railroad has compared the two types for wear — one side of the engine being fitted with rectangular rings and the other side with regular "L" rings. It appears that the valve having diagonal bridges and the broad rectangular ring was in perfect condition when examined after a year's service, and had all the appearances that would indicate another year's service without repairs, while the opposite side having the regular type of rings and bushings had to have chambers re-bored and new rings

applied. The general practice as regards the number of rings per end seems to be two rings, although several roads use three rings. It has been suggested that brass rings be used instead of cast iron, but I know of no case where they have been used.

A SNAP RING PLUG VALVE.

There is a patented piston valve on the market, prints of which I show. It is a well known fact that, theoretically, the plug valve is the ideal piston valve, but on account of the trouble of fitting and the inequality of expansion of valve and chamber this valve is not a practical thing. Considering the common snap ring valve, we find the steam has free access to the space below the rings and will force them against the valve chamber with full friction on steam pressure per square inch of ring surface, which in a valve ten inches in diameter and the rings only 1-2" wide, the frictional surfaces of the rings against the chamber exceeds 62 square inches. The valve is not, therefore, perfectly balanced, as is commonly claimed with the piston valve. This unbalanced feature is what causes the uneven wear of the valve chamber while working at varying cut off.

Referring to the sketch, an internal admission valve is

shown. The inner sides of the two snap rings (No. 1) are beveled. The other sides of the snap rings are straight, and fit against the straight walls of the valve spool. Against the beveled sides of the snap rings solid, uncut, non-expansible wall rings (No. 2) fit. Their inner sides are beveled at a greater degree of angle than their outer sides, which fit the snap ring. In between the two wall rings is placed a central, double tapered snap ring (No. 3). This ring is properly lapped and is put in under tension, thus holding the wall rings apart, putting a slight grip on the snap rings laterally. Thus applied, the action is as follows :—

When steam is admitted to the steam chest or central portion of the valve it passes through openings in the spool to the space beneath all of the rings, and acts simultaneously upon the snap rings and the central wedge ring. The snap rings are thus expanded against the casing at the same instant that the central wedge ring grips them there, and they are prevented from further expansion. This is demonstrated by withdrawing the valve from valve chamber while under steam until the first ring in the spool is entirely out of the cylinder, when no increase in the diameter can be observed. It can then be pushed right back into the cylinder again. It will be readily understood how easy it is to prevent further expansion of the snap ring by pressure underneath it, when the degree of angle of the bevel on the inside of the snap ring is considered. By making this degree greater, the power of the central wedge ring would be sufficient to decrease the diameter of the snap ring, closing it away from the valve chamber. It is claimed, therefore, that we have in this valve all the advantages of the plug valve without the drawbacks of the plug valve, all the advantages of the snap ring valve without the drawbacks of the snap ring, because we have practically a plug that does expand and take care of itself, not only for the difference in contraction and expansion, but also for wear, yet the plug is not so rigid as to knock a cylinder head out before relieving the water from the cylinder, yet it is absolutely adjusted to the diameter of the casing at all times, and is held there and allowed to get no larger during its work under pressure. The rings are so lapped that they are steam tight from all directions, and, by the bevel lap joint,

unbroken steam and exhaust lines at the edge of the ring are obtained.

This valve has been used on one or two roads, and it is claimed has given excellent results.

Except when the valve rod is very long, and even then, too, it is more of a necessity than in a slide valve to have a knuckle or Scotch yoke in the valve rod so that there will be no tendency for valve to rock. Any deviation from its true path causes the piston valve to bind and not only puts an extra strain on valve gear but also causes packing rings, valve, and bushing to wear more rapidly than otherwise. Unless the valve is very heavy it is not necessary to have an extension stem. The wear due to weight of valve is imperceptible. This extended stem has been used in solid external admission valves, however, to balance the area removed by the valve stem at back end of valve. One of the New England roads bothered by this unbalanced feature removed the difficulty in another way. They enlarged the area of the back end of the valve an amount equal to the area of the cross-section of stem. This road found that the unbalanced pressure on the front end of valve not only wore the valve gear but kept all the slack in one direction, and made the engine out of square. After the change was made no trouble was experienced.

It may be a matter of interest to many why, in using inside admission valves which require direct valve motion, that a non-reversing rocker is used with the eccentrics remaining the same on the shaft, instead of employing the same indirect motion as in use with slide valve and change eccentric to "back of axle" as it were. On the face of it this latter method seems to be the cheaper and simpler, but, in doing this there are several errors introduced in motion which are rather difficult to eliminate.

The angularity of the main rod, blades, etc., is quite a consideration in the design of a valve motion, but, in the general locomotive valve motion, it so happens that the angularity of main rod and blades, the location of blade pins back of link center line, and the varying influence of the two eccentrics working on the link all correct each other's errors, and give a motion so nearly correct that a small offset of link saddle-pin

will usually correct any remaining error, and give a motion cutting off equally at all points.

Reversing the position of the eccentrics in relation to the crank produces an irregularity of motion which calls for additional measures for equalization of cut off. The difficulty found in eliminating these errors thus introduced has caused it to become general practice to transmit the motion from the link block to a non-reversing rocker by means of a transmission bar. This last means has given general satisfaction.

Proper lubrication has been one of the great troubles with piston valves. In the majority of cases the oil is admitted into the live steam somewhere in its passage from throttle to valve, usually in the side of the saddle. The idea being that the oil dropping into the steam is atomized and in this kind of "oil-vapor form" is carried through valve and cylinder and the oil is deposited on all the surfaces with which it comes in contact. Seemingly this is an ideal method of lubrication, and in fact is the method employed to a great extent in stationary practice.

Cylinder oil, as generally used in railroad work, is heavy, and when it is dropped into live steam it is not entirely atomized, and falls into pockets in the casting where it remains to a great degree until blown out through a drain cock, which is usually connected with this pocket in valve chamber and operated by cylinder cock rigging. When drifting, practically no benefit is obtained from oil, and in fact the oil is wasted. When steam is shut off the oil drops into the pocket and lies there until some of it is carried over valve seat by current of steam when steam is again worked. But more likely the whole accumulation is blown out through drain cock.

In the slide valve there is a combination of this atomizing effect and straight surface oiling, that is, part of the drop is atomized, while that not atomized rolls or trickles down top of valve and over edge on to valve seat. Thus practically none of the oil is wasted. When drifting the oil acts entirely in the manner as last stated, that is, surface oiling.

It is necessary then to feed oil to valve chest of piston valve in such a manner that we obtain the same results as with the slide valve. This can be accomplished, I think, very well in the following manner. Bring the oil pipe down to a point just over

center of valve chest, as is usually done, but, instead of continuing the single pipe into steam main, place a tee in end of pipe and carry branch pipe to each end of valve chest, making pipe into chest over port into the cylinder. By this means, when the engine is working steam, the valve is lubricated by the atomized oil in live steam and also by atomized oil in exhaust, as they pass over valve bushing, etc., and further, the oil that is not atomized drops down, not into pocket whence it is blown out to waste, but on to valve as it works over port, or down into cylinder with flow of steam, where it is completely atomized and lubricates piston and cylinder. When drifting, the valve is lubricated, of course, by the oil dropping on it and what does'nt drop on valve drops down into the cylinder.

A western road is now experimenting on or with a method of oiling cylinders while engines are working steam, and oiling the valves while engine is drifting. In this method two additional oil pipes run from the two which now go through valve-cylinder and connect the main cylinder at indicator plugs. At the point of diversion there is a valve which when steam is being worked closes the oil way to valves and allows oil to pass directly into lower cylinder, and it is found that the valve is sufficiently lubricated by the exhaust as it passes out. Then, when steam is shut off, this valve closes the way to lower cylinder and leaves opening free to valve cylinder, where it is caught by the two heads of valve piston as they travel and reserve it until steam is again admitted. It is claimed this is a great improvement.

The greatest defect of the piston valve is its inability to free itself readily from excessive pressure, due to high compression or water in the cylinders. This defect is so serious, in fact, that any device which will satisfactorily overcome it will make the piston valve a success, as such defects as those due to lubrication and rings, etc., can be overcome as the valve is further developed.

The great merit of the slide valve is that it will lift and relieve excessive pressure in the cylinder.

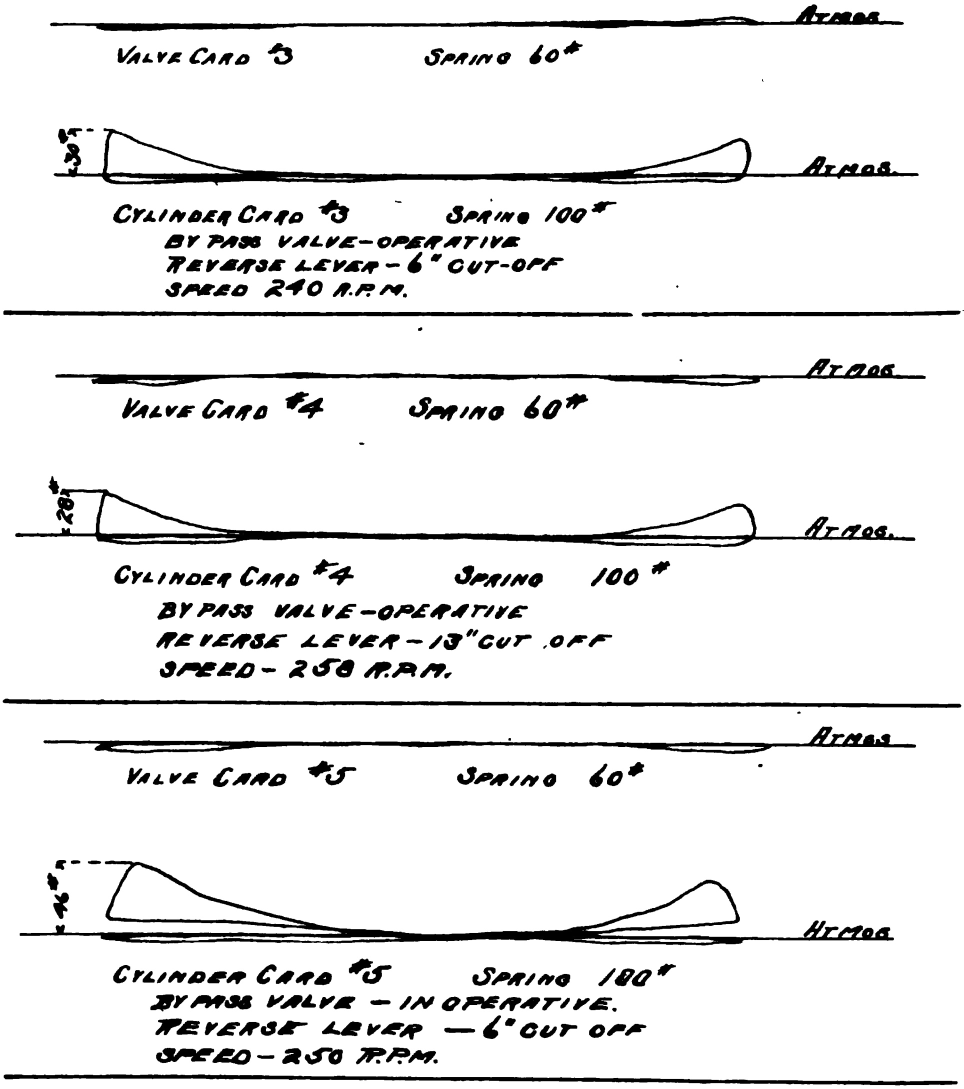
Many devices have been brought forth to remedy this defect of the piston valve, but none used so far have proved an unqualified success.

The by-pass valve is a common device for relieving excessive pressure. It is practically a check valve placed in a special passage between cylinder clearance and steam main. The steam pressure keeps the valve closed while steam is worked, but excessive pressure will open it against this steam pressure; when drifting, circulation is allowed between ends of cylinder. But when drifting at high speed this circulation doesn't take place readily, the valve keeps opening and closing very rapidly, not only hammering valve and seat, but tending to throttle the circulation. In fact, this hammering takes place so rapidly and with such force that the valve seat casting is soon broken, and the valve is practically out of commission. Moreover, if these valves are not carefully looked after the seats become worn, and steam leaks past and is wasted. On our road it has been found, too, that these valves are very likely to be gummed up with the cylinder oil and stick open, not only wasting steam but adding to back pressure in cylinder.

According to indicator cards which I have taken from a piston valve engine with and without by-pass valves, some advantage is shown by the use of the by-pass valve while drifting, but when working steam no advantage is shown. The N. Y. C. & H. R. R.R. originally had all their high speed Atlantic type engines equipped with by-pass valves and also relief valves in cylinder heads. Recently they have begun removing or blanking all the by-pass valves, and no difficulty is experienced so far as I can discover. It should be known, however, that this is a comparatively level road and little or no drifting is done.

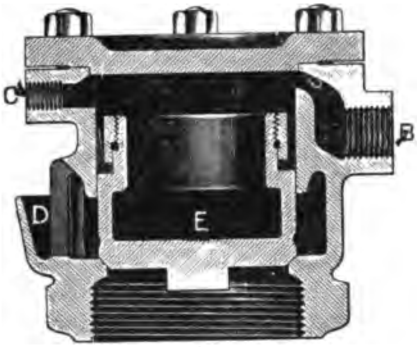
Very recently a new circulating device has been brought forth in the West which appears to be a very good thing, but has a serious defect according to my mind in that the pipe through which the circulating takes place is under cylinder and entirely exposed. It seems that all water in cylinder will drain into this pipe, and in cold weather will freeze and cause considerable trouble. Even if there isn't enough water in cylinder to lodge in pipe the steam passing through the pipe will condense and freeze and no benefit is derived from the device.

Pop relief valves in the cylinder head are used quite extensively. These may be set all right in leaving the shop but when it is necessary to have them operate they will be found



CARDS TAKEN WHILE DRIFTING WITH AND WITHOUT BY-PASS VALVE.

corroded and inoperative. If working all right these valves will be very likely to weaken and pop while working ordinary pressure in cylinder. To remedy these defects solid plugs in the cylinder heads have been used which blow out at a fixed excessive pressure, but these do not seem to be a success.



AUTOMATIC CYLINDER RELIEF AND VACUUM VALVE.

A Pipe to Cylinder. Into Steam Port.
B Pipe to Steam Chest. Live Steam Passage.
C Drain Cock. Exhaust Cock.
D Relief Opening.
E Differential Piston, lower base area 20 per cent. less than upper area.

I am at present experimenting with a new automatic cylinder relief and vacuum valve. Although I have no definite data as yet at hand, this valve apparently answers every purpose and, besides, is very simple and easily applied. There are no springs to break or corrode but the valve is held to a seat by steam chest pressure. This steam chest pressure acts on the top of the valve, which has an area 20 per cent. greater than the bottom, which is exposed to the cylinder pressure. Thus when cylinder pressure exceeds steam chest pressure 20 per cent., as when caused by excessive compression or water in cylinder, this relief valve is open and excess pressure escapes to the atmosphere. It also acts as a vacuum valve.

This matter of pressure relief is a very serious one, and the item of broken cylinder heads and cracked cylinders due to the inability of piston valves to relieve themselves of excessive pressure more than offsets any saving in general maintenance over the slide valve.

There is no doubt but that the piston valve is the easier to handle while using high pressure steam, but when drifting, moving the reverse lever much below the center of the quadrant becomes dangerous, as the lever will be pulled down into the corner with a jerk.

There are several opinions concerning the cause of dropping down into the corner and rocking of valve motion caused by it. One of the leading members of the A. M. M. A., an authority in locomotive construction, states the case as follows:—

He says in part: "Proper instructions should be issued to engineers for the proper handling of piston valve engines, to the effect that the lever should not be dropped down while the engine is speeding, but dropped down gradually as the speed decreases, as on going into a station. The object of this is obvious. The piston valve runs in a bushing, and not over a plain surface like the slide valve. Lubrication of the bushing and valve is taken on the metal, and the lubricating surface is that over which the packing ring travels. The surface covered by the exhaust which is not covered by the travel of the valve when working becomes dry and encrusted to a certain extent with the scum which you usually find in a steam chest. When you drop the lever in a gear you have to cut that all off at one stroke, practically speaking, or else it snaps in the packing rings and its packing rings travel over it, and the fact of almost dropping the lever down at speed is one of the most serious objections in the use of piston valves. It causes practically all the trouble of breakage of packing rings and the failures of the valve motion referred to. If the valve is handled in a proper manner, not dropped down when run at speed, but as you slow down drop it down gradually, there will be no trouble experienced with the cylinder."

The following is part of a report made to the Travelling Engineers' Convention. In part it reads as follows:—

"Herewith I give the results of an experiment made by me in order to satisfy our minds as to what the result would be by handling an engine equipped with piston valves on the lines recommended at the last Master Mechanics' Convention at Saratoga, namely, not to drop reverse lever from working notch while drifting. I experimented on engine No. 1001, a Brooks

ten-wheeler, running in first-class service. After the engine had worked steam constantly from Scranton to Gouldsboro, a distance of 21 miles, and a grade of 60 feet to the mile, steam pressure maintained at 205 pounds the entire distance, I applied an alloy that melts at 286° to the piston rod on arrival at Gouldsboro, but it would not melt. After shutting off the steam and drifting down the mountain I left the reverse lever in working notch. The speed ranged from 25 to 32 miles per hour. The distance the engine drifted was 24 miles when speed was reduced to about 25 miles per hour. Relief valves only opened a very short space of time and only just a very small opening as the engine was passing the centers. When speed was about 25 miles per hour the relief valve did not open at all. When about half way down the mountain I could smell the cylinders were heating up. I applied engine oil to the piston rods and a cloud of smoke arose from them. When about three-fourths of the way down the mountain I applied an alloy that melts at 286° temperature to the outside of the cylinder directly over the steam passage to front end of cylinder, but the contact was rather poor on account of the scale on the metal. Nevertheless, it melted. On arrival at the foot of the mountain we stopped and I applied the alloy that melts at 310° to the piston rod and it melted in five seconds. I applied an alloy that melts at 334° and it came very near melting. It softened up so that the lead pencil with which I held it to the rod made an indentation in it. This engine's valves were blowing quite badly at the time this test was made. Otherwise I am sure that the temperature would have been raised very much higher. It was also evident to me that if the speed had been increased to 50 or 60 miles per hour the temperature in the cylinders would have been so high that lubrication would have been of no benefit.

"On the next trip I experimented on the same lines, with the exception of dropping reverse lever to the corner while drifting, and at no time could the 286° alloy be melted, not even on piston rod at foot of mountain. This practice of leaving the reverse lever in working notch while drifting, may not work any serious results if only practised while drifting into stations — making stops; but I am satisfied that it will not

work on long descending grades, especially at high speed. It certainly will result in cut cylinders and valves, as you can get no benefit from the lubrication on account of increasing temperature caused by excessive compression."

I myself have found from indicator cards that while hooked up in the centre and drifting at the rate of 258 revolutions per minute, that the maximum pressure in cylinders when by-pass valves are operative varies from 25 to 30 pounds per square inch, while with the by-pass valves inoperative the pressure goes as high as 46 pounds per square inch.

When the lever is dropped 6 notches at the above speed while drifting, the maximum pressure varies from 18 to 28 pounds per square inch.

When the speed diminishes the pressure diminishes, as would naturally be expected.

The pressure in valve chamber exhaust ends remains the same with and without by-pass valves in operation — practically atmospheric pressure.

I have not as yet taken cards with the lever down in the corner while drifting, but hope to very soon.

The longest drift at speed during the tests was ten miles and the speed averaged 250 revolutions per minute. Even with by-pass valves blanked I could detect no undue heating of cylinders due to excessive compression.

A resume of the matter shows that the disadvantages of the valve lies chiefly in the difficulty of handling while drifting and the inability of the valve to relieve the cylinder of excessive pressure.

I admit that the defects, while few, are serious, and that a valve having the advantages of the piston valve and none of its defects, combined with the advantages and none of the defects of the slide valve, would be a perfect valve for railroad work. Such advantages, however, of the piston valve, as less cost of maintenance, ease of handling with high pressure steam on large engines, combined with the majority of advantages of the slide valve should make us consider the matter carefully.

This valve is new in railroad work, and a chance should be given it to be properly developed. Even now, it gives first rate satisfaction when intelligently operated, that is, if reverse

lever is not dropped while drifting at speed, and the water is not carried too high in boiler, and cylinder cocks are opened when steam is admitted to cool cylinders.

I would say, further, that I have the prints of this automatic cylinder relief and vacuum valve, and also details of piston valve and bushings and by-pass valve, if anybody should want to look at them.

THE PRESIDENT: I hope that these two papers are going to be illustrated by diagrams of the various valves described. Is it going to be practicable, Mr. Flory, to furnish diagrams?

MR. FLORY: I think so.

THE PRESIDENT: And Mr. Fitzgerald, also?

MR. FITZGERALD: For the Proceedings, Mr. President?

THE PRESIDENT: For the Proceedings. It will be much better if they are illustrated.

MR. FITZGERALD: Yes, sir.

THE PRESIDENT: This, gentlemen, is a modern subject in locomotive designing and building. I should be very glad to hear a relation of experiences. It was not many years ago that nobody supposed it practicable to use a piston valve, now they have come on with great rapidity. I hope we shall hear from gentlemen who have experience and gentlemen who have not.

MR. BARTLETT: Mr. President, my experience with piston valves extends over a period of about two years and covers about 50 engines. We have used both the inside and the outside admission hollow valve. I agree entirely with Mr. FitzGerald that the valves with the inside admission are by far the most satisfactory. In a general way, I feel that the piston valve has been fully as satisfactory as the slide valve with us. The engines go along every day without any trouble and do their work; and my observation tells me that the valve is an easier working valve, balanced well and has less back pressure; but I do feel that there are one or two things about it that I question, and that I particularly hoped to get more information on tonight. One of them — the most serious one, I think — with the piston valve, is the insidious leakage. I am quite sure that our valves are leaking more or less at times. I don't know how soon they begin after they get in service, or

just to what extent the leakage occurs, and I hoped tonight that somebody could have told us of tests to show the amount of such leakage. I feel that we ought more frequently, perhaps, to bore out our piston valve cases and renew our packings, but there is no particular telltale as to the leakage. We don't know just when to begin to get after it. It seems to me it is one of the most serious defects in the valve today, but I feel that it is something that can be overcome, and I hope somebody will have time to make some tests on the matter before long.

Another thing on the piston valve that troubles me a good deal is the matter of the by-pass. Our piston-valve engines are working on hills a good deal, drifting more or less, and we have had more or less difficulty with the by-pass valves. We use mostly the American locomotive type of by-pass. They blow and they stick up and have those various troubles. We have taken them out and run the engine without them without any apparent difficulty, but I am quite sure if we continued that long on hills that we should find trouble with the pounding of the main driving boxes that Mr. FitzGerald speaks of.

In a general way the operation of our piston valves, as I have said, has been satisfactory, fully as much so as the slide valves. I think a good deal of the secret of the satisfactory service of a piston valve is the care which is given it in operation. When we first got our engines with piston valves, we got out notices to every engineman calling his attention to the liability of water and saying that without extreme care damage would result. We have never had a cylinder head knocked out of any of those engines yet. Our men are cautioned — after the engine has stood a considerable time — never to start it without opening the cylinder cocks, as we don't rely entirely upon the other relief devices. The complaint that many others have had — of undue wear of the valve motion — we have not experienced. We have always had standing instructions on the road prohibiting the dropping down of the lever on all engines shut off at speed; and our directions to our men are to wait until the engines are almost slowed down. I think that has indirectly helped our valves and valve gear.

THE PRESIDENT: That refers to piston valves only, I take it.

MR. BARTLETT: Piston valves only. We do have that rule for slide valves or anything else. We found that we had trouble with broken eccentrics on all kinds of engines by sudden dropping down of the valve gear at high speed. We stopped that, and it has materially decreased our local trouble.

THE PRESIDENT: Have you experienced that difficulty that Mr. FitzGerald met when you dropped pretty well down, of getting a jerk on the reverse lever?

MR. BARTLETT: Yes. If we do that we find we have trouble, so we don't allow it.

THE PRESIDENT: The matter that Mr. Bartlett mentions, of the insidious leakage that is occurring with piston valves, is something that has always been charged to this valve, and I have had a good deal of curiosity myself to see whether the modern locomotive piston valve has been guilty of that defect. It would be possible with a piston valve or a slide valve to determine leakage, I should suppose, at intervals, by moving the engine until the valve covers both ports, and opening the throttle and the cylinder cocks and seeing how much steam comes out, and endeavoring to form judgment by observation in that way. It could be done from time to time.

Is there any other person who has any remarks to make on the subject?

MR. L. E. MERRILL: I have not much to offer, but I have had some experience with the piston valve type of engine. We had some trouble with that type. They were not developing the power that we thought they ought to develop, and the longer the rings remained in the piston valve the less efficient the engine seemed to be. I thought there would be a way of obviating that, by having a stated examination of the piston valve. There was one engine in particular in which we made a stated examination of the valve. Immediately after the valves were taken out, we noted an increased efficiency of the engine. There was no test made of the engine, but from what the engineer said, an increased efficiency of the engine was noticeable. I paid particular attention to the valves when they were taken out, and you could not notice anything exceptional in the ring; that is, the ring fitted the bushing to all

intents and purposes. To my mind it seemed that the spring of the ring had fallen off a little; that is, it did not quite fill the bushing.

The was one other thing that was brought out,—the fracture of the ring. You know the admission and cut-off release and compression are controlled by the rings, and when the rings are fractured — taking the admission and cut-off ring — you get an earlier admission and a delayed cut-off, and likewise on the compression and release ring, you get an earlier release and a delayed compression. The effect of the valve is that you are working the engine in fuller stroke than is apparent at the quadrant. Of about fifteen engines that were examined, only one was found that had a perfect set of rings. These were engines with a rectangular section of ring. Those valves were examined right along, and we had various results. The first time they were examined, and afterwards, we found anywhere from one to two or three rings broken in the valve. Those engines were only equipped with the piston valve on the side.

It appears to me that the question of fracture of the rings is quite important, and the suggestion that a brass ring be used might obviate that trouble a good deal. Of course, the brass ring might take a permanent set; then there would be a continuous blow; but then you would eliminate the question of fracture at least. There is no guarantee when you put a cast-iron ring into a piston valve that that ring will see any service at all before it breaks. It seems to me that that question of the fracture of rings is right at the bottom of a great deal of the trouble with piston valves.

The President: I made an effort to have Mr. P. M. Hammett, Superintendent of Motive Power of the Maine Central Railroad, here, and I think I should have been successful had it not been for the fact that one of the oldest members of the motive power department died and was buried today, and therefore Mr. Hammett could not be here; but he wrote me the following interesting letter giving an account of his experience with piston valves: —

MR. F. W. DEAN,
Exchange Building,
No. 53 State St.,
BOSTON, Mass.

Dear Sir:—

The question of piston valves is one of great interest to me and to most motive power officials at the present time, and we have most of us had enough experience with them in the last few years to make it possible to have a thorough and intelligent discussion of their qualities. On this road we have used piston valves in new constructions almost exclusively for nearly four years, and the results which have been obtained from their use are such that we should be very reluctant to abandon them. I cannot say that we have perceived any difference in fuel consumption, which could be attributed to the piston valves, but we have found that they handle with much greater ease, and that their repair account is very much less than with slide valves. As you are doubtless aware, quite a large portion of the failures of engines on the road is, in cases of engines equipped with slide valves, due to broken parts either of the valves or the yoke, and to breakage and wear of the valve stem packing. Thus far our experience with piston valves has been that no failures have occurred at all on the road which are attributable to the valves. Our repair account has been limited to the renewal of packing rings and an occasional renewal or boring of steam chest bushings when engines are in the shop for general repairs. I do not now recall that we have had a case of a broken packing ring in a piston valve. Of the various types of piston valve, very much more satisfactory results are obtained with inside admission valves than with the outside admission valve placed on top of the cylinder. This is, I presume, in part to be attributed to the shorter and more direct steam passages which are obtained when an inside admission valve is used and placed in the saddle inside of the frame, and in part to the better distribution afforded by the particular type of valve and the motion used with the inside admission valve. However this may be, we have found that the engines equipped with this type of motion and valve are distinctly smarter, and that they do better work on grades than those with the outside admission valve.

Yours truly,
P. M. HAMMETT,
Superintendent Motive Power.

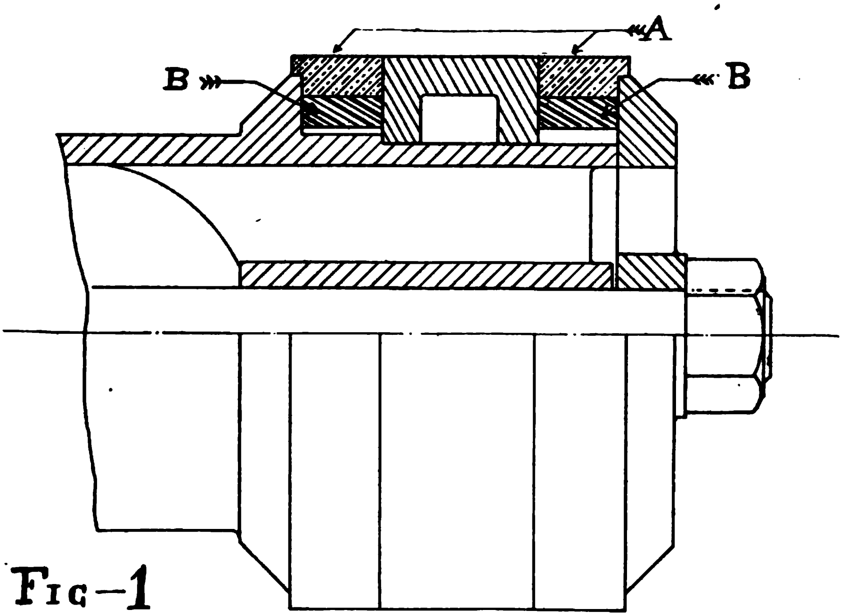
JOHN HECTOR GRAHAM: Mr. President, we had a gentleman here at the last meeting who, in an editorial in his paper some time ago on the heavy engine, said that railroad men were perfect fiends for following the fashion. That particular item struck me very forcibly. He might have gone on and spoken of the piston valve,—although I don't want to go on record against the piston valve. The speakers here tonight—both of them—referred to the effect of pressure and speed. It always makes me laugh when I hear of pressure—hear the railroad men talking about pressure. I was making a test not

long ago of a little two-cylinder engine, and a friend of mine connected with one of the railroads here came in. He said, "What are you doing?" I said, "I am just making a brake test with that engine." I had the gauge covered up so that if anyone straggled in he would not get alarmed. My friend said, "How many revolutions is the engine making?" I said, "About 600." He said, "What is the pressure?" I said, "The pressure does not amount to anything. I am going to get her up a little higher than that by and by." He walked over and lifted up the cloth that covered the gauge, and started for the door. I said, "What is the matter?" He said, "You have got 700 pounds pressure in that boiler." I said, "That is nothing. Wait a little longer, and I will put on 900." The railroad men throw up their hands when they talk about 200 pounds steam pressure, and here are these automobiles running round here every day, and there is not any man that knows anything about an automobile that does not carry 300 pounds pressure in the little boiler — that brake test with a plain Allen valve and with 600 turns a minute and with 750 pounds of steam.

G. S. Webster: I have seen a brass packing ring used in piston valves, as shown in Fig. 1 at A, with a steel spring ring shown at B to keep the brass ring against the valve cage. This steel ring should be machined so as to fit properly between follower and bull ring and between bull ring and valve spool. This packing ring should have a properly designed joint piece (not shown in sketch), which should travel back and forth on a bar in valve cage parallel with the bore. All other bars can be on an angle if preferred. I have seen this ring used in valves from 1 to 22 inches in diameter with good success.

The President: I might add that I have not yet seen a railroad man who threw up his hands when 200 pounds pressure was mentioned. It seems to me that 200 pounds is ancient history now. We are now dealing with 225 a good deal of the time.

Mr. Graham: I might add that I see that the Great Western Railway of England has just imported a compound from France, and that steam pressure is going to be 225 plus 2 — making 227 pounds pressure on that engine.



FIG—1

THE PRESIDENT: Mr. Leach, haven't you something to offer on the subject of Piston Valves *vs.* Slide Valves?

MR. LEACH: Mr. President, I was trying to recollect just what each of the speakers said, but I don't know that I have it right in my mind, and if I have not I trust that one or the other will correct me. It appeared to me, as I remembered the remarks, that they contradicted one another. The first speaker said, I think, that one of the advantages of the piston valve was less wear to the valve motion. I can't remember whether the other speaker said that there was more wear to the valve motion, but he did mention cases of excessive wear to the driving box. It would appear to me that if we had excessive wear in main driving boxes, there must have been resistance at the piston ——

MR. FITZGERALD: Due to the unbalanced pressure on the valve. I was talking there about a solid valve where the exhaust was unbalanced,—that is, at one end it was 54 pounds, say, and the other end was 22 pounds pressure at the same time. That unbalanced pressure all acted on the main work, of course, and took up all the slack and gave a pound on

the eccentrics,—and of course that means the driving axle and, therefore, the box. But that only refers to the solid valve — inside admission. I have taken some cards here on the hollow valve, and I find there is not as much pressure,—practically the two ends are balanced. That is due to the fact that the steam can flow from one end tó the other. .I don't claim that the wear on motion is due to that unbalanced pressure in a hollow valve.

Mr. Leach: Well, I would like to ask,— as I don't remember whether you said anything about that or not,— do you think there is more wear to motion work with the piston valve than with the slide, or less? Just briefly.

Mr. FitzGerald: Well, in a case where they are using the transmission bar and heavy motion work I think there is, compared with the lighter motion work of the ordinary slide valve.

Mr. Leach: That is what had appeared to me. As I was going to say, it seemed, where one gentlemen stated that there was less wear to valve motion by the piston valve, in the other paper the intimation was that there was more. Of course we are all privileged to our opinion, backed up by observation or by facts. It is my opinion that we surely don't have any less wear to the motion work with the piston valve than with the slide valve, particularly if it is on a road that is not level. And then the wearing of the main driving boxes, as mentioned in the second paper, is something to give us thought. I have heard of cases of that kind, very serious cases of that kind. Then as regards Mr. Bartlett's remarks, that with his piston valve engines he had never had a case of a broken cylinder head, and one or two other things. I don't remember whether they had any broken valve rings or not. Do you know? Plenty of broken rings?

Mr. Bartlett: Not "plenty"; we don't have any epidemic of them.

Mr. Leach: Well, as regards broken cylinder heads, etc., I have talked with a good many gentlemen who have had to do with piston valve engines, and I must say, from Mr. Bartlett's remarks, that he is very fortunate. Personally I don't care to express my opinion at this time in regard to piston valve *vs.* slide valve, although I must admit that it is very decided, prin-

cipally from being directly influenced by results which I have attributed to things that might not have been so, and therefore I am not prepared to state my opinion, as I said, because I might be open to further education in that line.

I don't know that I have anything more to say.

MR. FLORY : Mr President, referring to my paper on the wear of piston valves *vs.* slide valves, I got considerable of my information from the proceedings of the American Master Mechanics' Association of last year, and the concensus of opinion was that they had less wear and tear with the piston valve motion than with the slide valves. Of course, with a solid piston valve, which both myself and Mr. FitzGerald quoted, both running at slow speed, you will have excessive pressure on one end of the valve, but what causes the wearing of the driving box brasses I cannot say. If I remember rightly, in this report of the Master Mechanics' Association there was only one road which gave as one of the disadvantages of piston valves the wear of main driving box brasses, and why it was so they did not state. I don't remember whether they used the solid valve in that case or not.

THE PRESIDENT: Mr. Flory, you come from a drifting railroad, so to speak, that is, one with grades miles long and very steep, and I believe most of your quotations have been with reference to the experience of other railroads, but perhaps I am mistaken about that. I should like to hear what you are doing on the Lehigh Valley.

MR. FLORY: On the Lehigh Valley we have only a few simple engines with the piston valve, while of course all of our compound engines have piston valves. They are used mostly on the level divisions. For the light service and the passenger service, we use slide valve engines, and have quite a number equipped with the American high pressure balance slide valve ; while we have some trouble with them, we find they do very good work.

THE PRESIDENT : There is one point that has not been mentioned, I think, tonight, and that is the comparative weight of the two types of valves. I should like to know which valve is the heavier usually.

MR. FLORY : Concerning the usual type of slide valve I have

not any figures, but I do not believe that the weight is very much less than the piston valve. In the American high pressure balanced valve the valve is made very light. It has a double port opening, and I don't believe the valve weighs over 25 or 30 pounds. I have never weighed one, but I don't believe they weigh more than that.

THE PRESIDENT: Mr. Purves, aren't we going to have a word from you tonight?

MR. PURVES: Mr. President, I don't know that I can say anything of interest, or contribute any additional information to the very interesting subject under discussion.

Theoretically, as well as practically, the piston valve is no doubt all that can be desired. You are all familiar with its general construction,—a spool-shaped piston valve, fitted with nicely adjusted packing rings at either end, the whole traveling through a smoothly bored cylindrical valve chamber. It undoubtedly performs the functions of steam admission, distribution, and exhaust, in as perfect a way as does the common slide valve.

Notwithstanding, however, the combined beauty and perfection of the piston valve, I am inclined to believe that locomotives equipped with piston valves have given us more trouble on account of machinery failures than have locomotives that are not equipped with them. These failures may have been due to the manner in which the engines were handled by our enginemen, and I am very glad that our friend Bartlett has a class of enginemen who understand thoroughly the handling of piston valve engines.

The Boston & Maine have never had a broken cylinder head on this type of engine. Well, the Boston & Albany have, and many of them, and broken cylinders also.

This does not cover all our troubles. We have had many main rods bent,—piston rods bent; in consequence of which cross-head shoes and guides were damaged,—all this occurring from no apparent cause; that is, no cause traceable to defects such as broken main rod strap, piston rod key, etc.

I have seen 4″ piston rods bent to an angle of 45° and cross-head shoes torn from guides, from no apparent cause, but which must have been caused by water in the cylinder. This

cannot be attributed to the piston valve, but I never have known of a slide valve to use a poor piston rod in that manner.

Less than two weeks ago, an engine equipped with a piston valve broke down between Worcester and Boston, and the valve motion was badly disarranged. In an interview with the engineman, he said that as soon as he closed the throttle, the reverse lever flew out of the quadrant, and we all know the results expected when the lever of one of these engines goes into the corner. This engine got those results.

THE PRESIDENT: Where was the engineer?

MR. PURVES: The engineer was on his seat, and my inference was that as soon as he closed the throttle, he attempted to drop the reverse lever, but he said, "No, I did not." He was positive that the lever went into the corner without any assistance on his part. I possibly may have doubted him, but as I was not on the engine, I was obliged to accept his statement.

On that engine, both transmission bar pins, 1 3-4" diameter, requiring a blow of 7,000 lbs. to break one, were broken off like pipe stems. I am not prepared to say that the piston valve was in any way responsible for this accident, but I never saw the valve-motion of a slide valve so completely put out of business. Almost every one is agreed that it is suicidal to drop the lever down on piston valve engines while running at speed with throttle valve closed, and that cylinders have been equipped with by-pass valves and safety valves, in order to relieve compression and condensation. The slide valve in itself acts in the capacity of both.

I have no hesitancy in saying that the reason for broken cylinders and cylinder heads on piston valve engines is more attributable to water in cylinders than any other cause. This is caused by condensation, of which there are two kinds. One form of condensation takes place by reason of the steam at high temperature coming in contact with the cooler walls of the cylinder casting, and the other form is caused by the man on the right side carrying the water above the danger line to such an extent that it is carried through the throttle valve and steam pipes into the cylinders in so large a quantity that it cannot be taken care of by the cylinder cocks or relief valves, and an engine failure follows.

As far as cost of repairs to either type of valve is concerned, I think the piston valve leads; but taking into consideration all other troubles that we have had with piston valve engines, there is a question in my mind in regard to general all-round benefit or advantage of the piston over the slide valve for locomotive practice.

THE PRESIDENT: While these piston-valve engines were bending 4-inch piston rods and breaking off 7,000 pound other rods, etc., what happened to the valve itself? Did that stay in good shape?

MR. PURVES: Some of the packing rings may have broken or the heads of the valve chamber knocked out, but either of these would have been of minor importance when compared with the other damage sustained. I am unable to give the cause of such terrible havoc to valve gear on a piston-valve locomotive when the reverse lever is dropped down while running at speed shut off. I thought possibly that we might have some reasons or theories advanced tonight in the papers that were read. It has suggested itself to me that possibly the heavy motion work has something to do with it. With heavy eccentric strap and rods, heavy links, transmission bars and rocker arms and valves, the weight is enormous; and when we consider that it is obliged to come to a sudden stop in its very fast career, and retrace its steps only to be as suddenly stopped again and returned in the opposite direction, I am not surprised that something happens. At speed, the momentum of the swinging parts increases rapidly with the increase of travel of valve.

If anyone else has anything to advance in regard to this question, I would like to hear from them.

MR. WEBSTER: I do not think it is the momentum put into the piston valve that tears the valve motion to pieces. It must be something else, that railway engineers should be familiar with. In torpedo boat and destroyer engines they use larger and heavier valves than are used on horse-power locomotives, and they do not have any very great trouble with the valve gear. Engines on these boats turn up from 400 to 600 revolutions per minute.

I should think that if the reverse lever drops down in the

corner as described, it would be well if American locomotive designers would copy some of the designs they use abroad, and use either a steam reverse gear or a hand wheel and worm with toothed quadrant, so that the reverse gear would not get away from them and do the great damage attributed to the piston valve.

THE PRESIDENT: I suppose that in torpedo-boat-destroyer practice the valve-travel is much less than 6 inches, as it is on locomotives frequently.

MR. WEBSTER: I should say offhand that the travel of the valves on these boats vary from 4½ to 7 inches, depending upon who are the designers and builders. The French engineers use the longer travel when the stroke of the engine goes to 22 inches. Probably the maximum travel in general practice is about 6½ inches, which makes a very high valve speed, as you can readily see.

THE PRESIDENT: Mr. White, I feel tempted to ask you in regard to the prevalence of orders for piston valves *vs.* slide valves, that is to say, do the majority of orders call for piston valves or slide valves nowadays?

MR. WHITE: It seems to be the fashion to have the piston valve,— the majority going that way,— but there are a number of roads that have been finding some trouble and have been going back to slide valves.

THE PRESIDENT: I remember — I think it was a year ago — when Mr. Vauelain was here somebody asked him about piston valves, and he said that he did not advocate piston valves for simple engines, but that on his four-cylinder compound he could not help using them, and that is the reason he did.

Mr. Bartlett, we shall be glad to hear from you.

MR. BARTLETT: I just want to extend my sympathy to my friend, Purves, and to say if he thinks all these troubles are attributable to piston valves, then I certainly think he is justified in going back to slide valves. Not only do I say we have not had a cylinder head knocked out, but I don't recall that we have had a broken eccentric strap. I don't think it would be very hard to tell what the engineer did at Worcester with the engine he refers to.

Mr. Purves: I have a guess at it.

Mr. Bartlett: On general principles it would seem to me that trouble would occur on any engine — piston valve or not — which was dropped down at high speed to full stroke shut off, and you would expect to tear something out. I know we should if we did it, and we don't do it. I don't think the piston valve is alone in that.

Mr. Desoe: Certainly the piston valve is a good valve in some points. When you have a road that is using steam all the time, and have got good clear water, and have dry steam, they will go all right. Less than three months ago I took an engine out of Springfield. She had been lying there quite a while. I used a big tank of water, one with 4,500 gallons, enough to carry me 75 miles, I used it in going 25 miles, because the engine was foaming, but I got over the road and I got the train home. If I had had a piston valve I should have stayed just outside the depot at Springfield; I could not have moved. After I got the engine down so that she did not foam I went right along. But with the piston valve you could not stir. The minute you get water or damp steam on the valve, something has got to give way on the engine. And about this man that was spoken of. He told me he liked to have got killed. I just unhitched the latch — I had no idea of dropping it,— but it yanked me almost through the cab.

Mr. Purves: I am much obliged to you for the information.

The President: One of the greatest yarns I ever heard about a piston valve engine was that a packing ring sprang into a pout, so that the valve could not move. It locked the steam in the cylinder, so that the piston could not move, and of course the wheels could not rotate; they slid along on the track, and when the engine stopped they could not move her. After disconnecting they found the axles and frame so bent that the engine could not be hauled home, and she had to be loaded on a car and carried in. I wish to add that I do not believe the story.

Mr. Bartlett: Mr. President, I understand Mr. Baker has had some experience with piston valves. I should like to know what he has got to say.

MR. BAKER: Misinformed, Mr. President.

THE PRESIDENT: Mr. Baker does not deal in that kind, ordinarily, I suppose.

MR. LEACH: Mr. Chairman, I would like the privilege of asking Mr. Bartlett if he ever noticed any undue wear of the main driving boxes with the piston valve engines?

MR. BARTLETT: Yes, sir.

MR. LEACH: To what do you attribute that?

MR. BARTLETT: I don't know exactly.

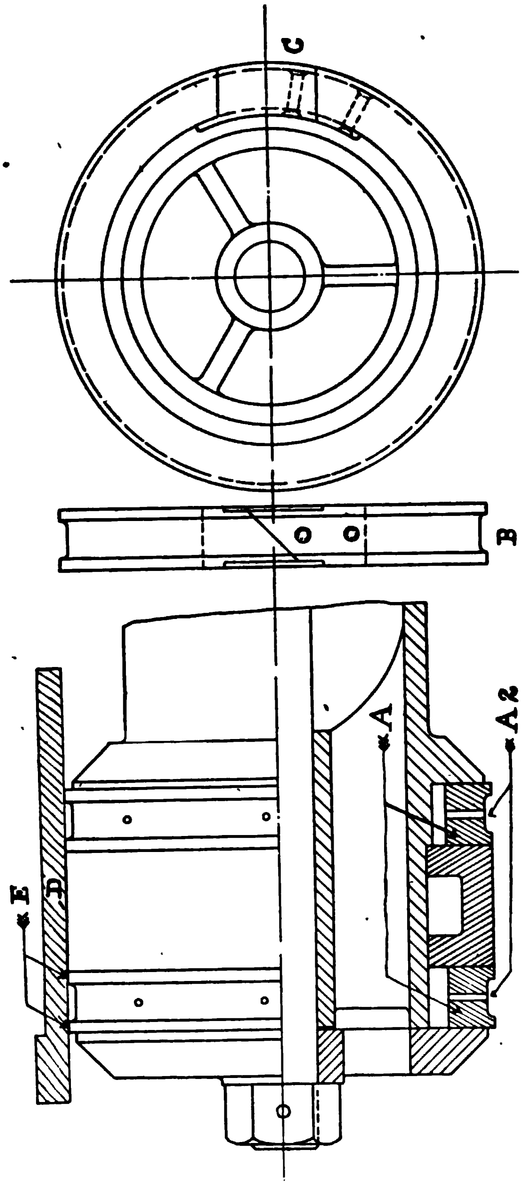
THE PRESIDENT: It will be proper for Mr. Flory and Mr. FitzGerald to make any closing remarks that they desire.

(NOTE. — Here the President withdrew and the chair was taken by the Vice-President.)

MR. GRAHAM: Mr. President, I would just like to say a word. Some time ago I saw a description of a solid piston with a solid piston ring, made by the Thorneycrofts, and I am sure our friend Webster back here knows something about that. He can tell us how it is done. A solid piston head, with a solid piston ring.

MR. WEBSTER: In reply to Mr. Graham, I know a little about what he speaks of. A man by the name of Perkins designed and used on tow boats on the Thames River, London, England, a piston packing made of a special metal resembling babbitt, capable of withstanding very high temperatures, which Mr. Thornycroft now uses on torpedo boats in the horse-power cylinder. This man Perkins used very high pressure steam, — very often 350 pounds. It is said, and with truth, that the principal reason that engineers have trouble with piston valves is that the rings used to prevent leakage of steam give the greatest trouble, — either the steam gets in behind them and presses them against the walls of the valve cage and causes them to wear unduly, or they break from the same cause.

There is a packing ring used that I think will overcome these troubles, and with your permission I will make a sketch of it: Fig. 2, in which D represents the walls of the cylinder or valve cage; A is a section of the packing ring itself; A2 is a space turned out of the diameter of the ring about 60 per cent. of its width with holes as shown, drilled so that any steam



Fig'-2

that may get behind it as it passes over the steam ports to cylinder will exert a nearly equal pressure, both on the back of the ring and face of same when it travels past the port and gets on the solid part of valve cage. The only part of this ring that is not balanced is at E, which is just enough to keep it out in place under different working conditions.

This ring works best with a joint piece as shown on plan B, and at C in elevation. By close examination it will be seen that as ring moves apart at diagonal cut it will not leak past ring in either direction. This sketch (Fig. 2) will show this ring as used on a 7 or 8-inch piston valve. It will be seen also that as the ordinary packing ring travels over the steam port and steam accumulates in the cylinder the tendency of the rising pressure is to cause the packing rings to collapse, and, after it has passed over the port, to snap out against the valve cage, which in time will cause the ring to break. This new ring (as shown) overcomes this difficulty, and has never been known to fail under any pressure.

The Vice-President: Any further remarks, gentlemen? If not, I would like to ask Mr. Flory if he has any remarks to offer in closing.

Mr. Flory: Nothing, I think.

The Vice-President: Have you, Mr. Fitzgerald?

Mr. FitzGerald: No, sir, I have not.

The Vice-President: If no other gentleman has anything to offer——

Mr. Purves: Mr. President, I move that a vote of thanks be extended to Mr. Flory for his kindness in coming so far from his home to Boston to give us information and knowledge on the subject that he has so well in hand.

(The motion was seconded and was adopted unanimously.)

The Vice-President: The subject is closed. I want to say, in addition to a brief statement that was made at the last meeting, that the subject for the February meeting is "Safety Appliances." We shall consider the Safety Appliance Act. This is a very important subject, and I think we can make the meeting a very interesting one. Mr. Moseley, the Secretary of the Interstate Commission, will be here, and will probably deliver the talk of the evening, which will open the discussion.

We are desirous also of having some Interstate Commission Inspectors here. We are not sure of that, but we anticipate it, and hope that we may have them. We want to let Mr. Moseley see, and the world see, because our Proceedings go all over, that we are interested enough in this subject to come here, every member, and to come prepared to talk upon it, if we are able to; if not, to ask any questions upon it that may occur to us. I think I am correct in stating that there will be a copy of the report of the Interstate Commission mailed to each member. After you have read that, and have digested it, you will know a lot more than you do today, and perhaps you can come prepared to ask Mr. Moseley questions as to things in the paper that you cannot grasp. That is mailed to you with the idea that you can become familiar with the topic for the next meeting. We want you all to come here and take an interest in it. We want the largest attendance at the February meeting that we have have had this year.

There is another announcement to make, and that is, that two weeks from tonight we have our Ladies' Night. Any of you that were here last winter when we had our Ladies' Night can say that we had a very fine time. We intend to have another fine time two weeks from tonight, and whether or not we have any more in the future will be entirely dependent on how many make it their business to attend, or at least to buy tickets. Tickets are for sale by Mr. Barbey and his assistant in the other room, and I deem it is every member's duty to go out and pay $1.00 for two tickets, whether he wants to come or not. We had more than a dollar's worth last year. We have a fine entertainment, a nice little dance, a lunch, and an all-round rattling good time.

Has any other gentleman anything to say? If not, a motion to adjourn is in order.

(Adjourned, on motion of Mr. Baker.)

MILTON ROBBINS,

DIED DECEMBER 14, 1903.

New England Railroad Club,

February 9, 1904.

SUBJECT FOR DISCUSSION:

SAFETY APPLIANCES.

Paper by Mr. GEORGE GROOBEY,

Chief Inspector of the Interstate Commerce Commission.

E. L. JANES, SECRETARY, SOUTH TERMINAL STATION, BOSTON, MASS.

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The regular meetings of this Club are held at Pierce Hall, Copley Square, corner of Dartmouth Street and Huntington Avenue, Boston, on second Tuesday of each month, excepting June, July, August and September.

NEW ENGLAND RAILROAD CLUB

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$1.00 A YEAR. *Boston, February 9, 1904.* 15C. A COPY.

A REGULAR MEETING of the New England Railroad Club was held at Pierce Hall, Copley Square, Boston, on Tuesday Evening, February 9, 1904, at 8 P. M., Vice-President W. B. Leach in the Chair.

The following members registered:—

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Adams, W. H.
Allen, C. Frank
Archibald, F. B.
Austin, Frank P.
Averill, A. B.
Baker, C. F.
Banks, W. H.
Barbey, F. A.
Bartlett, Henry
Bigelow, Chas. H.
Bodwell, G. Arthur
Cade, Wm. E.
Chaffee, E. F.
Chain, E. E.
Chamberlain, H. M.
Chase, R. G.
Copeland, Thos.
Eddy, F. H.
Ewart, John
FitzGerald, J. M.
Gehman, G. W.
Gilman, John H.
Goodwin, C. E.
Graham, J. H.
Graves, C. W.
Greenwood, H. A.
Gurry, Geo.
Hammett, P. M.
Hartwell, H. B.
Hayward, Josiah P.
Hibbard, L. J.
Ingraham, F. F.
Janes, E. L.
Kanaly, M. E.
Keay, H. O.
Kelliher, John
Lanza, G.
Leach, Henry L.
Leach, W. B.
Lindall, John
Lindley, R. M.
Lord, G. W.
Marden, J. E.
Marden, J. W.
Martin, G. W.
McCombs, Henry W.
Merrill, C. F.
Merrill, L. E.
Moran, Andrew
Morse, E. H.
Nesdell, F. F.
Olson, G. S.
Patten, J. W.
Pickford, Samuel
Quilty, J. P.
Randall, Chas. E.
Rice, Edmund
Richardson, A. H.
Smith, C. B.

Smith, Frank
Smith, W. C.
Spencer, J. H. C.
Spinney, E. D.
Swett, Geo. W.
Thorp, F. P.
Towle, J. M.
Watson, J. W.
Webster, George S.
Wetherbee, F.
Whall, F. R.
White, A. M.
Woodward, C. N.

THE VICE-PRESIDENT: The first business of the evening is the approval of the minutes of the previous meeting. Those minutes will be ready to mail in the course of two or three days, and they will stand approved as they are printed. I think there are no errors.

Reports of Committees. Are there any committees to report?

THE SECRETARY: No committees to report.

THE VICE-PRESIDENT: Unfinished Business.

THE SECRETARY: Under the item Unfinished Business, we have a proposed amendment to Article IV. of our By-Laws, which was read at our meeting last month. The article if amended will read as follows:—

"The initiation fee shall be five dollars, which shall include the dues until the next annual meeting, and the annual dues thereafter shall be two dollars, payable in advance on the second Tuesday in March of each year, of which one dollar shall be in payment of one year's subscription for the printed Proceedings of the Club at the published price. Members whose dues remain unpaid at the annual meeting in May following, shall forfeit membership and all rights and privileges of the Club. Nothing in the provisions of this article shall prevent delinquent members from making new application, and said application shall be subject to the same action as in the case of application of new members, with the exception of the initiation fee."

You will observe the only change in this article has reference to the first two or three lines which I read, making the initiation fee of five dollars cover the dues until the next annual meeting, where heretofore an additional two dollars has been required to cover the dues until that meeting.

THE VICE-PRESIDENT: That is to be voted on.

MR. BAKER: Mr. Chairman, I move we accept the amendment as read.

(The motion was seconded.)

PROF. ALLEN: Does that require a majority vote or a two thirds vote?

THE VICE-PRESIDENT: A majority vote, isn't it, Mr. Secretary?

THE SECRETARY: No, sir, a two-thirds vote.

THE VICE-PRESIDENT: Are there any remarks?

(The amendment was adopted unanimously.)

THE VICE-PRESIDENT: Any other unfinished business, Mr Secretary? Any New Business?

THE SECRETARY: Under the item of New Business, your Executive Committee has accepted the following gentlemen as members of the Club: — Mr. John F. MacEnulty, sales agent of the Pressed Steel Car Company, New York City; Mr. Henry H. Lynch, president of the Hodge Boiler Works, East Boston.

THE VICE-PRESIDENT: The gentlemen whose names have just been read were elected members of this Association at the Executive Committee meeting this evening. Is there any other new business?

THE SECRETARY: I know of none.

THE VICE-PRESIDENT: The appointment of committees. By the way, I should have prefixed the business of the meeting by giving an excuse for my being in the Chair at this time, and that is, that we have received a letter from our President stating that he had an appointment of long standing for this evening that he could not let go and requesting me to be here. He has appointed a Nominating Committee, and I will ask the Secretary to read the names of the committee as appointed by him.

THE SECRETARY: Nominating Committee — Henry Kolseth, chairman, C. H. Bigelow, J. M. FitzGerald, John T. Boyd and Charles H. Wiggin.

THE VICE-PRESIDENT: Any committees to report?

THE SECRETARY: No, sir.

THE VICE-PRESIDENT: We now come to the subject of the evening. As the notice said, it was inferred that Mr. Moseley, secretary of the Interstate Commerce Commission, would be with us this evening, but the Secretary has received a letter which I will request him to read, which will explain.

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INTERSTATE COMMERCE COMMISSION,
OFFICE OF THE SECRETARY,
WASHINGTON.
EDWARD A. MOSELEY,
Secretary.

February 2, 1904.

MR. EDWARD L. JANES,
Secretary New England Railroad Club,
Back Bay Post Office, BOSTON, MASS.

Dear Sir:—

I have your letter of January 28.

I have looked forward with pleasure to the meeting on February 9 of the New England Railroad Club, so many of the members, like myself, being citizens of the Commonwealth, and have felt that it would be productive of much good, not only to the members of the Club and myself, but to the proper understanding of the subject to be discussed. It is, therefore, with the greatest regret that I find, owing to the condition of my health, that I shall be unable to attend the meeting, and the fact that I am thus prevented from being present is far more disappointing to me than I can express. However, Mr. George Groobey, our chief inspector of safety appliances, will avail himself of your kind invitation to attend the meeting and will bring with him, if possible, such other inspectors as are in that section of the country. Mr. Groobey thoroughly understands the mechanical part of our inspection, in fact far better than I do myself, and he knows the aims and objects we desire to obtain by that system. I have no doubt his visit will be a profitable one to all.

With kindest regards to the membership, I am,

Sincerely yours,

EDWARD A. MOSELEY,
Secretary.

THE VICE-PRESIDENT: Mr. Groobey is with us this evening, and he also has with him three of the Interstate Commerce Commission's inspectors,— Messrs. Merrill, Watson and Auchter. Mr. Groobey is to open the discussion with a paper or remarks, and, as he said to me in discussing the best method of procedure for the evening, the other inspectors will probably fit into the discussion. If they don't, why we will have to call on them. I take great pleasure in introducing Mr. Groobey, the chief inspector of the Interstate Commerce Commission. (Applause.)

PAPER BY MR. GEORGE GROOBEY.

Chief Inspector Interstate Commerce Commission.

Mr. President and Members of the New England Railroad Club:

On account of the illness of Mr. Moseley, Secretary of the Interstate Commerce Commission, it is my privilege to be with you this evening as his representative. Mr. Moseley fully expected to be here tonight, and it is a great disappointment to him, as I am sure it is to you, that he is unable to be with you, but at the last moment he was advised by his physician not to venture upon the trip.

In acting as the secretary's substitute I feel somewhat at a disadvantage, as I had but little time to prepare a paper or even to think over what I would say on the important subject of safety appliances. This question, which I trust will be fully discussed by your club this evening, has so many ramifications that it will be only possible for me, at this time, to touch briefly on what would seem to be the most important.

As some of you know, I was for a number of years engaged in the railway service, and in your reception of the few observations I will make on this subject, I hope you will consider me one of yourselves.

Federal regulation in the matter of safety appliances was believed to be necessary to bring about uniformity in the use of them for the purpose of attaining certain results. The time was fixed by Congress when these safety appliances were to be installed. The enforcement of this law was lodged with the Interstate Commerce Commission, which was also vested with authority to extend the time fixed by Congress, at the expiration of which time the safety appliance act was to become effective. A most natural development was the inauguration of some method to keep the Commission informed as to the progress the railroad companies were making in their compliance with the provisions of the Act. Thus came into existence the government inspection of railway equipment.

The framers of the law wisely refrained from specifying any particular kind of appliances that should be used or any particular method of their application. In other words, the railroad

companies were given free hand to adopt any devices, and to apply them as their practical experience suggested in order to comply with the statute. For good and sufficient reasons shown, the Commission at public hearings extended the time when the original law should have become fully effective, then fixing the limit at August 1, 1900. As soon as practicable after that date a systematic inspection of the railroad equipment was commenced.

Realizing full well the technical character of the inspection that would be required, the Commission corresponded and consulted with many of the best mechanical and operating men in the country before a book of rules governing this inspection was finally adopted. For a period of about two and one-half years after the law became operative, an inspection was conducted that might well be considered educational in character. This educational period was essential for at least two good reasons, one of which was to familiarize the Commission with the true condition of the equipment, and what, if any, improvement was made. The other reason was to call the attention of railroad companies to the condition of their equipment by furnishing to them statements of the defects found by inspectors of the Commission, the object being to bring about improvement.

This plan, as I have stated, was continued for more than two and one-half years, and I regret to say that the result hoped for — that is, the improved condition of safety appliances — was not realized to the extent that might be expected. It became necessary, therefore, for the Commission to adopt a more drastic method, unpleasant as it was; that is, to commence a number of suits for failure of railroad companies to comply with the provisions of the safety appliance laws.

I have given you a brief history of the inspection of railway equipment as it has been and is being conducted by the Interstate Commerce Commission. At the conclusion of my remarks I will be pleased to answer any inquiries in my power in regard to this subject, from the members of the club.

It would seem to be proper at this time to bring to your notice what I consider the more important provisions of the safety appliance laws.

1. In regard to driving-wheel brakes on locomotives.
2. Appliances for operating train brakes.
3. The use of fifty per cent. or more of power brakes.
4. The use of automatic couplers.
5. Hand-holds on cars and locomotives.
6. Standard height of couplers.

In regard to the first item, that of driving-wheel brakes, it can be stated that the requirements of the law are practically complied with. Out of approximately 40,000 locomotives in use in the United States but a very small number, which are of obsolete types, and are used only in cases of emergency, are found without the driving-wheel brakes.

Appliances for operating train brakes. Under this head it is a pleasure to state that much credit is due to the proper officials for their manifest desire to bring the passenger equipment in this respect up to a high standard of efficiency, as exemplified by the constantly increasing use of what is known as the high-speed apparatus. It is to be regretted, however, that the appliances for operating train brakes on locomotives assigned to freight service are in many instances insufficient. I speak of appliances in a broad sense and allude more particularly to the small pump and the inadequate reservoir capacity, the disadvantages of which will be briefly referred to under the third item, which relates to the use of fifty per cent. or more of power-braked cars.

Under this head a great deal could be said, but, owing to the limited time for preparation at my disposal, I do not feel that anything approaching a thorough review of this most important provision of the safety appliance law can be gone into this evening. It may be observed, however, that many of the difficulties of the past are fast disappearing, due largely to the better opportunities afforded railroad employees to understand the working and maintenance of air-brake appliances. This better understanding of the employees, as I have said, will help to a considerable degree; yet I wish to impress upon you the need, in many instances, of a pump large enough to furnish a greater volume of air, with a correspondingly increased storage capacity. A few years ago, when fewer air-braked cars were used, the smaller pump was satisfactory; but with the long

trains of today and the greater number of air-braked cars in use, the demand for appliances that will furnish the maximum capacity in all respects seems to be imperative. It has been stated that the use of a larger pump will encourage neglect of the train line; but it is believed that, as the air brake repair organizations become perfected, this condition need not be feared.

An especially noteworthy feature of the air brake situation is that on the most mountainous roads the air brake is maintained in almost ideal condition, and its aid to safe operation is appreciated, while on many low grade roads we find the conditions regarding maintenance very poor, and are told that the air brake cannot be relied upon. The same people tell us that in regard to the mountain roads ideally perfect condition is absolutely necessary. The deduction is that the fellow who does not feel the weight of necessity is not doing his full duty when he fails to get satisfactory results under less exacting circumstances.

In this connection I call your attention to the importance of the application and maintenance of retaining valves. It has been and is now our practice to make no report of the absence of these parts on cars on which this particular appliance has evidently never been applied. There are indications, however, that this practice will have to be discarded, and that we will be called upon to report, as defective, all air brake cars not equipped with the retaining valve. One of the most common causes of brakes being cut out is that engineers complain of not having sufficient air. The fact that the retainer holds air in the cylinder, and thus increases the power of the whole apparatus at the very time needed, appears to be a sufficient reason in favor of its general use.

Some experiments are now being conducted in an endeavor to increase the braking power of loaded high capacity cars. This question is one that should be thoroughly gone into; and as I have noted on several occasions that the air brake talent in this section of the country is fully up to the average in ability and enterprise, so the result of a full discussion of this matter by your Club should be of material assistance in solving this difficult problem.

I desire to call your attention to the practice observed on a road in the Northwest, whose traffic is principally iron ore. They have a closed season when very little business is done, and a part of this dull period is taken advantage of to thoroughly inspect and repair all the air brake apparatus. The results following this practice have proved to be so satisfactory that I mention it here in the hope that other roads having dull periods may be led to follow the example. Those who have been connected with the mechanical departments on many roads know that it is the common practice to do the opposite of this. When business falls off, forces are decreased, and the equipment consequently is in poor shape when needed.

The use of automatic couplers.

I have no doubt we all feel the importance and need of a more complete study of this feature, but full discussion of this matter cannot be had tonight. As far as our opportunities permit we are investigating some portions of the automatic coupler. It will be some time, however, before the results will be known.

In a few moments I will invite your attention to some of the comments made in the analysis of defects as reported by the inspectors to the Commission.

The use of handholds on cars and locomotives.

The method of application of this part to cars is steadily improving. The question of handholds on locomotives has, as you know, been the subject of investigation by a committee of the American Railway Master Mechanics' Association, and their report has been made public.

The standard height of couplers.

Little need be said regarding this feature, as almost ideal conditions exist.

I would like to call your attention especially to the 83,000 defects found on 60,000 cars out of 220,000 inspected during the year ending June 30, 1903. As you know, our inspection covers a few parts of the car only. It is not conducted as a railroad company's inspection is, covering all parts of the car, but merely covering "safety appliances."

For the year ending June 30, 1902, out of the total number of defects appearing on this sheet, 7.84 per cent. were found in

couplers and parts, and were separated in this way: Broken coupler body, broken knuckle, broken knuckle pin, broken lock pin or block, bent lock pin or block, wrong lock pin or block, wrong knuckle pin, worn lock pin or block, worn coupler or knuckle, short guard arm, missing parts of couplers, inoperative lock, bent knuckle pin. As I say, the percentage last year was 7.83, as compared with 8.39 for this year, showing either that our inspectors are becoming more expert, or that the couplers are getting into a worse condition.

The next classification is Defects in Uncoupling Mechanism. Last year 41 per cent. of the defects found by our inspectors were in uncoupling mechanism; this year they are almost 43 per cent. This again shows that our inspection is becoming more expert or there are more defects.

The next classification is Visible Parts of Air Brakes. You lal understand that our inspection of air brakes is necessarily confined to visible parts. If we should undertake to inspect the working parts of the air apparatus we would have many of the trains in the country tied up. Last year the percentage of defects found in visible parts of air brake mechanism was 42½; this year it is reduced to 37. This is really the only encouraging feature in the table, showing that some positive progress is being made, and it is very gratifying to find it in such an important feature as the air brake.

Two other features, Handholds and Height of Couplers, are constantly showing a betterment. Carrier irons is a feature that we included two years ago. We found such an extraordinarily large number of them loose, and the effect of loose carrier irons had such an important effect on the uncoupling mechanism that we included them in our inspection. This year, I am glad to say, we note a great improvement in that feature. Side Sill Steps is a new feature, and it is surprising to find the large number of side sill steps in a dangerous condition. I remember that when I was an inspector on a Western railway I would pass a good many cars before I would ever think of trying a side sill step. I would see it there and pass right along. I would not think of putting my hand on it, or touching it with my foot to see if it was secure to the car. It is a very important feature. I hope that our calling attention to it in this way will result in some better conditions.

Other features are Ladders and Roof Handholds. This question of roof handholds is one that should create some discussion. As you know, the Master Car Builders have recommended the application of a roof handhold in a longitudinal position, regardless of the location of the ladder, and some trainmen in various parts of the country are taking vigorous exception to that practice. They claim that the roof handhold should be placed in a position relative to the ladder. It is a subject that could well be taken up and thoroughly gone into by this Club.

Some comment on defects of couplers will be of interest. The items *broken coupler body, broken knuckle, and broken knuckle pin* do not appear to call for any special comment, but the item *broken lock pin or block,* it is regrettable to note, shows an increase. This defect exists most commonly on foreign equipment. The evident weakness of this part is significant in view of the tendency to employ parts of more or less complex design. There ought to be a thorough investigation of such parts. It would disclose the causes of conditions which are frequently responsible for the necessity of men having to go between the ends of cars to open or adjust couplers. Lack of knowledge of these parts by the average trainman, and in many instances by car repair men, is an added reason why their use should be carefully considered.

The necessity for examination of the internal parts when defects exist, attention to which is called in items *broken lock pin or block, bent lock pin or block, and inoperative lock pin or block* — these three items all refer to the lock pins or blocks — requires men to go between the ends of the cars. When this is necessary it implies a defect which means a violation of the law, and a coupler which thus induces men to take dangerous risks is thereby condemned. It is difficult to measure in what degree the individual acts of the trainmen contribute to casualties, but if the couplers were so made that defects could be discerned from a safe position the responsibility of the carriers using them would be reduced.

The lack of inspection of couplers and the failure to use the worn coupler gauge recommended by the Master Car Builders' Association, is responsible for many difficulties in the operation of trains.

In the proceedings of the Master Car Builders' convention in June, 1901, it is stated that it is impracticable to use this gauge at interchange points by reason of its requiring the separation of cars. The distance between the front wall of the coupler and the pulling face of the knuckle for new couplers, when the correct contour exists, is 3 1-8 inches. If, when a train or string of cars is to be inspected, the brakes are set on the rear and the lost motion is taken up by the locomotive, it would seem to be possible to ascertain the deviation from contour by measurement or by an adapted gauge, and those parts found exceeding a prescribed danger limit to be established, say, for illustration, a half inch, could then be given more particular attention, and if, as stated by the coupler committee, it is not suspected that coupler bodies are at fault, the renewal of a knuckle, knuckle pin, or a lock would restore a safe contour.

The item *broken uncoupling chain.* The decrease of 2 1-4 per cent. in this item is indicative of increased care of chains. This defect is one which has continued to attract notice, and is due largely to the difficulty of adjusting and maintaining chains at a correct length and to the use of such a substitute as wire. The apparent improvement is, perhaps, due to a closer analysis by the inspectors for the commission to ascertain the causes of chains being disconnected, which formerly were all reported as "broken." Such chains are now classified under missing clevis, and clevis-pin missing. The greater percentage of defects is found on foreign equipment.

The extraordinary increase in the number of clevises and clevis-pins missing is evidence of weakness in these small parts and of the fact that a closer inspection is made as to the cause of chains becoming disconnected. The clevis-pin is frequently missing, and this condition is often followed by the loss of the clevis, and it is then, of course, reported as clevis or clevis-pin missing, or both.

Take that defect in connection wih the item *bent uncoupling lever,* of which the following comment appears:—

"The conditions are approximately the same as last year, and it must be admitted that this defect is likely to continue. These levers are exposed in various ways to disarrangement. The facts should convince an impartial observer that many

casualties which occur during coupling and uncoupling are caused by yard switchmen and trainmen having to exert unusual effort to operate a bent lever while running along beside cars in motion. Again, cars receive many severe shocks because of the inability of the men to give signals to the engineer on account of both hands being employed—one in the attempt to operate the lever and the other in holding to the grab iron. This condition is undoubtedly responsible for innumerable failures of parts of the car and damage to lading."

A review of the conditions of uncoupling mechanism for a period of years appears in an appendix to the Safety Appliance report. With your assistance, Mr. Janes, I will see that every member gets a copy.

In conclusion, attention is directed to the unlimited field for investigation of the several items upon which comment is made.

Committees on subjects for discussion before the various technical associations frequently express their inability to obtain suitable subjects for debate, and it is suggested that when that difficulty arises some item or items be selected from the table accompanying this report, which will furnish ample material and bring to notice that neglect of little things which so often results in dangerous failures of cars or engines.

Many of the higher mechanical officers seem to be unable to give the consideration to small defects which, nevertheless, is so essential to the economical and safe operation of our railroads. It is to be hoped therefore that the railroad clubs and car foremen's associations will take up these and other matters shown in the present record.

I believe we are all prepared to acknowledge that the existing conditions are susceptible of improvement. Therefore, two profitable topics at this time are, "Who is responsible for the existing conditions?" and "What can be done to remedy the situation?"

Referring briefly to the first topic, it may be said that divided authority is accountable for the existence of defects, and if this is the case, it follows that a more perfect system is necessary. A little thought suggests that often the officer held responsible for the state of equipment is unable to obtain the force he deems necessary to maintain a safe standard, and he conse-

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quently feels a lessened sense of responsibility. Upon whose shoulders has this measure of responsibility from which he feels relieved been placed? This illustration will disclose my meaning when alluding to divided authority, and discussion along this line, participated in by all the interested officials, will, I believe, result in improved conditions.

Regarding the suggested topic, "What can be done to remedy the situation?" I would say that we must first come to a full realization of what is needed, and our efforts must be directed toward ascertaining the facts so that they may be properly presented.

For the last three years the number of defects found on each defective car has been for 1901 1.24; for 1902 1.28; for 1903 1.37. This indicates one of two things — either that our inspectors are becoming more expert in detecting the specific defects, or that a greater number of defects are allowed to exist.

For the year ending June 30, 1901, 198 employees were killed and 2,768 were injured in coupling and uncoupling cars. The per cent. of defects found in the uncoupling mechanism for the same period was 66.37 per cent. For the year ending June 30, 1902, 143 employees were killed and 2,113 injured in the same occupation. The per cent. of defects found in uncoupling mechanism for this period was 41.07. Note the decreased number of casualties and the decreased per cent. of defects found in uncoupling mechanism.

Is there not some connection between these facts? Shall we not say that improvement in the uncoupling parts would result in a lessened number of casualties to employees whose duty it is to operate these appliances? The percentages of defects quoted are in relation to the whole number of defects found on cars inspected each year.

I hope that some part of what I have said may incite discussion. It is my belief that a general exchange of ideas will result in a deeper knowledge than could come from any one person's experience or a paper.

Mr. Moseley appreciates the cordial relation which exists between the Commission and the organizations of railroad officers and employees. Their co-operation and assistance have

made his work in connection with the Safety Appliance feature a pleasant duty.

Had I known earlier of this agreeable assignment I would have endeavored to prepare something more elaborate, but, if discussion ensues, one of the objects of my visit will have been accomplished.

I thank you for your invitation to be present at your meeting and for your attention.

THE VICE-PRESIDENT: Following out the suggestion of Mr. Groobey, we will proceed to the discussion of this paper, and the inspectors will probably fit in, as he has suggested. I want to say right here that Mr. Merrill, one of the gentlemen mentioned before, is the inspector who spends a great deal of his time in this district. Some of you know him and perhaps would like to get a chance to get back at him or he at you. Gentlemen, I don't want to call any names here tonight, but we will have to do it unless you volunteer.

MR. GRAHAM: Mr. Chairman, after an absence of two weeks I came home and found this Safety Appliance document in my mail, and I sat down and spent the time in reading it thoroughly. I must say that I am delighted to have such a brochure in my possession. In going through it I made several notes, and I guess we can get discussion up after I cover them.

First of all, the brake hanger. Take the floating type of truck — the box girder type — that has its weight poised on springs on the axle box, when the car is standing empty it is braked to 70 per cent. of its weight; when you get the load in the car is braked to 25 per cent. of its weight, but owing to the fact that the brake shoes travel down with the compression of the springs, you have about 16 per cent. of your weight braked. That is something that the Interstate Commerce Commission might give its attention to. That is a dangerous fact that exists every day — every loaded car braked 16 per cent. of its weight every day on the railroads of America. Think it over.

Then the couplers. It is impossible to maintain the standard height of the couplers under the same conditions — the variation of the car body when loaded as against the empty car body — and the uncoupling in transit results. The report

says that 43 per cent. of them are defective. If any railroad man that has the least idea of the cult of the railroad business will read that report and then say that the vertical plane coupler, with its knuckle, is not a failure, he is denser than I am, because this report says that the vertical plane coupler is really a failure as at present designed,—that is, with a swinging knuckle. They will have to come some day to a solid coupler—without any shifting knuckle, or pin, or lifting link or anything—to make a vertical plane coupler a success.

The report also goes on and covers the fact that owing to the extraordinary heavy business we have had on the railroads in the last two or three years, the defects and the breakages and the losses and the accidents have accumulated. I thought I would just make a comparison,—that is, taking the facts out of this brochure and comparing them with facts that I had in my library. I found that in Great Britain in every 100 miles there are 98 locomotives, and in America there are 20. I might add here that the little Lancashire & Yorkshire Railroad that runs across England—500 miles—has 1,000 locomotives. The coaches in England to every 100 miles number 307, and in America 18. There are 3,167 freight cars in England, and 719 freight cars in America for every 100 miles. We go on the principle of the big load and the long haul, and, as near as I can understand, the Britisher does his business on the retail plan as against our wholesale business. Here we have a comparison of rolling stock per 100 miles. With the facts of this brochure, the enormous increase in accidents all along the line, anywhere you please, by the very figures in this book you see how the Britisher is constantly reducing, reducing, reducing everything in the way of accidents, so that for fifteen months in Great Britain they did not kill a single passenger.

Now the Interstate Commerce Commission inspectors can explain the book. (Applause.)

THE VICE-PRESIDENT: Mr. Bartlett.

MR. BARTLETT: Mr. President, I have been so busy that I have not had time to read the report, and don't feel just ready at this minute to say much on the subject. I should like to

hear from some of the inspectors as to just what the character of the defects is where the safety law is not complied with.

MR. GROOBEY: First of all, Mr. Bartlett, we must have an understanding. The law requires the use of an automatic coupler. Is it a violation of law if any one part of that coupler is out of order? If the law requires an automatic coupler, and for some reason or other that coupler will not work, that is I think, generally a violation of law. Therefore, when a car found having a coupler with any one of the classified defects which we have here, all of which have been admitted to be necessary to the proper working of the coupler, it follows that a defect exists. In couplers and parts, as I have said, we find a certain percentage of defects on so many cars inspected this year, running almost to 8 1-2 per cent.

Now we come to Uncoupling Mechanism. Is the coupler automatic without the use of some uncoupling mechanism, and does it comply with that requirement of law which says cars shall be uncoupled without men having to go between the ends of the cars? It would seem to follow that some device or some method is needed to fully comply with this requirement of law. We have, for the purpose of conducting our inspection intelligently, arranged the items we have in our book of rules to fully describe the defects in detail. We have in the neighborhood of 30 defects to uncoupling mechanism. We find in that class 43 per cent. of defects on the cars inspected for this period.

Our inspection of visible parts of air-brake is, as I said a little while ago, confined to certain parts, and I hesitate to accept the suggestion of my friend here with reference to including brake hangers. Brake hangers are a very essential part of the brake apparatus, and it may be found necessary some day to include them, but I think until all cars are equipped with air-brake apparatus we had best keep away from the hangers. Is that an answer to your question, Mr. Bartlett?

MR. BARTLETT: Yes, sir. Thank you. I recognize that.

THE VICE-PRESIDENT: The paper as read, as I look at it, seemed to speak more particularly of the cars. I have no doubt there are locomotive men here tonight, and in fact I know there are, who would like to have the subject of the Safety Appliance Act as it applies to locomotives, brought to more particular

attention. Isn't there some locomotive men who would like to ask a question? If not, I am going to ask Mr. C. F. Merrill to stand up here and turn his back to me, so that the rest of them can hear, and tell us of the troubles that he has every day as applied to cars, and also to locomotives. Mr. Merrill, you are in our vicinity. Tell us of the conditions on these New England roads. There is a New England man sitting right beside you. It will do him good to hear you talk. Mr. Merrill, gentlemen. (Applause.)

MR. C. F. MERRILL: Mr. President and Gentlemen of the New England Railroad Club: I don't think your President has given me a fair chance, because I have not been in this vicinity long enough to say what your real conditions are. I have made some inspections here, and I don't think that you are any worse off than any other localities that I have been in, as far as I have been.

Relative to the safety appliances on engines, I think that Mr. Groobey, our chief inspector has covered that point. The matter was left to the American Railway Master Mechanics' Association, and it is under discussion, as I understand, at the present time, and it is to come to some adoption between now and the first of March. I will say that I have found quite a number of grab irons gone from the tenders, or they never have been applied to engines, in this locality, and in some instances I have found no levers on the tenders of engines. Then, again, I have found road engines being used as switch engines, without any footboards on either end of the engine. Of course, the matter of grab irons on the front of locomotives we have paid no attention to whatever, because that has, as I say, been left for discussion by the American Railway Master Mechanics Association, for them to agree upon a type of grab iron that they desire to use on the front ends of locomotives.

I must be frank at this time in saying that in my opinion the great difficulty in the minor defects, such as clevises, clevis-pins and broken chains, to a great extent occurs by the neglect of men in yards, that is, they go along and don't realize the importance that it is. This is a great thing and I think if every railroad would get its foremen, or chief inspectors, or inspectors

—all of them—and educate them up to the importance of these little things, there would be a vast improvement in a very short time. I don't think that it is done wilfully, but just simply that they don't realize what it means to a trainman who is required to switch and uncouple cars. I find in my travels also that at times there is not the required amount of help in some of the large yards for the vast amount of cars that are handled. And another thing I will have to say that I have found, and have had occasion to take it up, where the men are not given the opportunity to inspect these trains as they should be inspected, that switch engines are coupled on and the trains are torn to pieces before the trains are given the inspection that they should have after going over a long division. I think, gentlemen, that this is one of the most important parts of railroading, that trains should be given a thorough inspection at each terminal, which I must say in a great many instances is not done, for the lack of having time to give it the inspection before the switchmen tear the train to pieces and it is scattered all over the yard.

Another thing that I think is important is the matter of cutting the hose. I have had occasion in the West to go around with officials to see which was the best way to overcome the difficulty of cutting the hose before trains are switched. From my knowledge and experience as a train service man, I will say without fear or favor, that as long as there are railroads you will never get a switchman to cut hose, and in order to overcome that it has got to be taken up in some other way. Now, I will just illustrate. One place in particular that I was at was Milwaukee, on the Chicago, Milwaukee & St. Paul. The Assistant General Superintendent had taken up the question of what was the best way to do that and save time. Well, they started out one day, and they had the car repairers cut the hose between every car. That, of course, took time on their fast freight runs. And then they tried another plan, which was that the car checker who marked the train, wherever there was a switch to be made, cut the hose where the switch was to be made. The last time I was on that system they were putting that mode into adoption, that is, the man that marked the train for switching would cut the hose wherever there was to be a switch made,

which of course overcame a great deal of time in coupling up the hose connection when they got ready to go out.

I don't know that there is anything more, gentlemen, that I can say. If there is any question that I can answer I shall be glad to do it. I must say that in the time that I have been at this work my relations with all the officials that I have had occasion to come in contact with have been very pleasant. I think the inspectors have always met with the hearty co-operation of any official that they have ever had occasion to call upon, and any suggestion that they have offered I know has been heartily received.

I desire to say as to one particular point that I think these inspectors should be educated as to the importance of the safety appliances, and I think they could be educated on this point. I believe the proper way is for the Interstate Commerce Commission to furnish copies of the rules we follow in making our inspections to the Railroad Inspectors, to show them what we call defects, which shows the importance of missing clevis and broken chain to the men that have to go between the cars on account of these defects when doing switching and setting out a car on the road. I thank you. (Applause.)

THE VICE-PRESIDENT: I was under the impression that this meeting would be somewhat similar to one that we had some time ago on the subject of blacksmithing. There were about half a dozen gentlemen that evening who could not wait for an opportunity to have the floor, and I thought that was about the way it would be tonight. I thought they would be coming so swiftly that it would be pretty hard work for a man to get up here and talk, because there would be someone else on the floor. But that is generally the way here. When we have a meeting that we think is going to be particularly active and interesting, it generally turns out the other way. Now, it does not seem to me possible, with as many railroad men as are gathered here at this time, that there should not be a very lively discussion on this subject.

Mr. Hammett, cannot you favor us? We don't see you here every night.

MR. HAMMETT: There is one question that occurs to me that I would like to ask, and that is whether the Interstate

Commerce Commission has taken any attitude with reference to the necessity of a knuckle opener as a part of a coupler. It is my impression, or recollection, that the law speaks particularly with reference to the provision of means for the opening of the couplers, or uncoupling the cars, without men being required to go between them.

MR. GROOBEY: Section 2 of the Safety Appliance Act reads:

"That on and after the first day of January, eighteen hundred and ninety-eight, it shall be unlawful for any such common carrier to haul or permit to be hauled or used on its line any car used in moving interstate traffic not equipped with couplers coupling automatically by impact, and which can be uncoupled without the necessity of men going between the ends of the cars."

That law, as written here, stands today without any interpretation by the Interstate Commerce Commission in any way, shape, or form.

MR. EDDY: I would like to ask how many different kinds of couplers there are in existence today throughout the country of the M. C. B. types.

MR. GROOBEY: Previous to my connection with the Commission I believe there was prepared a tabulated statement of number and kinds of couplers used, but some four years ago they stopped collecting that information. At that time, I believe, there were in the neighborhood of 80. There are no official figures to my knowledge on that subject now, but speaking in a general way I should say possibly 30 different kinds are used in sufficient numbers to make it necessary to speak of them at all.

THE VICE-PRESIDENT: Mr. Laffey, ask these gentlemen some question. You can talk as well as anybody.

MR. LAFFEY: Mr. Chairman, I have nothing to say.

MR. GROOBEY: If I might make a suggestion, Mr. President?

THE VICE-PRESIDENT: Yes, sir, we would be very glad to have you do so.

MR. GROOBEY: There is one subject I would be very glad to hear about. That is the question of using retaining valves.

Some roads having very low grades or level roads don't seem to think that they have any obligation in the matter at all. We cannot go to them and say that they are wrong. It rests with organizations of the character of yours to bring out the desirability of the use of retaining valves, and I should think it was something that this Club could very well take up. I certainly would like to hear expressions of opinion on that particular feature.

THE VICE-PRESIDENT: Are there any of the air-brake men here tonight? I don't seem to find any. Mr. Eddy, cannot you tell us something about the retainer?

MR. EDDY: I will say that the road I am with applies retaining valves to all cars, excepting passenger equipment.

THE VICE-PRESIDENT: Is there a New Haven inspector here anywhere?

MR. CHAIN: Mr. President, I at one time had something to do with air brakes on cars, and my impression is that the Westinghouse air brake people furnish a retaining valve with all equipments. I am surprised to learn that any road equips a freight car without putting on this retaining valve. I know that the Boston & Albany Railroad makes it a practice to apply the retaining valve to all cars when equipping them with the air brake; my impression was that all other roads did the same thing. The retaining valve goes with the set, or with the equipment for a car, and it only requires a few feet of pipe to apply it to the car. I should suppose that all roads use it.

THE VICE-PRESIDENT: Mr. Watson? Mr. Auchter, wouldn't you like to favor the members of the New England Railroad Club? Mr. Auchter, gentlemen, another of the inspectors. (Applause.)

MR. GEORGE T. AUCHTER: Mr. Chairman and members of the New England Railroad Club.—Gentlemen, I do not know that I can tell you anything that would enlighten you or add anything to what Mr. Groobey, Chief Inspector for the Interstate Commerce Commission, and Mr. Merrill, also an inspector, who have preceded me, have said. But the gentleman over there, in another part of the hall, who just compared American railways with those of England rather nettled me. (Laughter.) I wish to say to you I have never been in Boston before, and

have never visited this part of the country before; and today, while I had a few spare moments, I said to my colleagues, "I have a relative up here on a hill, and I would like to go and see where it is." I went up to Bunker Hill, and right in frcnt of the Bunker Hill Monument there is a piece of statuary, and on its base is inscribed the name of "Colonel William Prescott." Well, he is a relative of mine, or would have been if he had lived — a great uncle or somewhere thereabouts. You will readily see that the moment the gentleman spoke about England and compared its railways to those of this country, it kind of nettled me after visiting the statue of that tried patriot. However, that has no bearing on the Interstate Commerce Commission, or the law that was enacted that created this commission.

Now, if you will look back with me, some ten years ago there was a law enacted regulating, practically speaking, the traffic of American railways and the charges that should be made to the shipping public and the travelling public, and, in some measure, to make shipment, travel and employment safer; and last, but not least, to protect the actual owner's property. I believe, if I put the right construction on the law, that was its aim and object — to protect the shipper, to protect the passenger, to protect the lives of the railway employees.

As you well know, the government sends a certain number of employees about the country to see that that portion of the law that protects the lives of the passengers and railway employees and the shippers is lived up to; and you, gentlemen, are employed by the railway, in your various capacities, to operate its trains and transport the passengers and freightage over the country, and, in a good many instances, as cheaply as possible consistent with safety. But on a great many roads I am inclined to believe the safety question is not strictly adhered to at all times and under all conditions, for I have had twenty-three years of practical experience in various capacities of service, and I speak from an experienced standpoint. The very fact that this law has been recorded on the statute books for ten years in this country of ours, shows that it has been of some benefit. The American public would never stand silent for ten consecutive years for a law that is wrong, and feel it

drawn tighter and tighter and extended in scope from year to year, as this Interstate Commerce Act has been to the present time. If I understand it right, no one has offered any remonstrance against the range, scope or authority of the law, to be broadened or tightened upon that very feature that I speak of. If there has been any adverse influence manifested, it has not been felt; it has not become generally known; our public press has not recorded or printed any such adverse criticism, or any desire on the part of any citizen to amend or repeal said law.

Now, as I said before, I believe it is a benefit. I believe it to be a benefit to you and me and every one else that rides, that ships, or that works on the railway. That being the case, if the influence of the act has reduced the number of accidents on railways in the United States, it has certainly protected the owner of the property, it has certainly protected to a measure the lives of the people that have traveled; and Mr. Groobey, Chief Inspector, has this evening given you facts and figures showing the great saving of life and limb of railway employees in the past ten years, due largely to this act and the generous co-operation of the operating officials of the American railways.

In that way I feel that I am doing some good. I believe I am doing good all the way through. I don't look at it from a one-sided standpoint, that I am only working for the employee's interest; I don't feel that way. I feel that I am assisting, in a measure, in protecting and safeguarding the traveling public, the employee, and also the railway property to its actual owner. That is my aim, and I am also firmly convinced that is the desire of the Commission and all of its inspectors, more especially that noble gentleman, Mr. E. A. Moseley, Secretary of the Commission, who has made this his life work; who has spent time, funds and energy in perfecting this Commerce Act and its influences; and the commission is doing just what we have proven to you this evening by facts and figures. And I believe that when any man lives in this world, and goes through it and does not do some good—does not benefit the human family to some extent—his life is practically lost; he dies, and is forgotten. (Applause.)

I thank you, gentlemen, for the kindness of inviting me here this evening, and for the courteous treatment accorded me; and

I shall always look back with pleasure to the meeting of the New England Railroad Club. Again, I sincerely thank you.

THE VICE-PRESIDENT: The first speaker mentioned the defective couplers, worn knuckles, pins, etc., which constitute a large portion of the defects that the inspectors find. In connection with this I would like to say that I know of one road, one of the large systems of the country, that is giving this matter very serious consideration. They have decided that the worn knuckles and pins, which are worn so as to allow the contour of the coupler to go beyond the limit, are giving them a great deal of trouble, and trouble which can be eliminated if proper inspection — I will define that, proper and systematic inspection — takes place. I believe that question is being considered to the length that on certain portions of the system, as the trains are brought in, before the engine cuts off, the brake is to be set on the buggy and the engine pulled ahead, thus stretching the train, setting the brake on the head car, and the engine then go off about its business and the inspectors go along, and they can almost tell at a glance — in fact, they can tell at a glance — that some of these couplers are beyond the limit. If there is any question, they have a little gauge, I believe, or they are going to have a little gauge, that will just drop down and enable them to tell. They hope that by discovering these defects and correcting them, the number of break-aparts and other damage resulting from those defects will be reduced. I simply mention this as there does not seem to be any one here in a position to mention it.

Prof. Allen, won't you have a little something to say to us this evening on this subject?

PROF. ALLEN: Mr. President and gentlemen, I don't feel that there is anything I can say on this subject. I came, as I generally do, to learn, and as it is no part of my duty to come in contact with defective apparatus I am not in a position to discuss the matter. When some general principles are involved I occasionally get a chance to say something; but the matters involved now are largely matters of detail, and, unfortunately, I am kept so busy that I don't see as much of the cars in active operation as I would be very glad to do. I would be very glad to get into the railroad yard and spend a lot

of time in it. Unfortunately, I am not able to do so. Today, for instance, I find that the Railroad Club is the third club or society which has demanded two or three hours of my time, and this in addition to my regular work of teaching. In the meantime, I have not had much chance to study a matter that is not easily in my line of work. I am very sorry that I cannot discuss it.

THE VICE-PRESIDENT: Mr. Woodward, cannot you talk to us from an operating standpoint?

MR. WOODWARD: Mr. President, I don't know that I can say anything more than perhaps ask one or two questions, which might stir up some of these car people here. My experience with the retaining valves has been that one reason why they were not used more was because they did not retain the air. Our train men don't place a great deal of dependence on them. They seem to feel that if they want to slow the train up when going down hills the best way is to put on two or three hand brakes and go down the hill that way. I believe that is perhaps caused because the retainers are not given the care that they ought to be given. I would like to hear what the inspectors have got to say about it.

We had a slight accident the other night, caused by a defective knuckle pin. The train separated and put the brakes in quick action. The car that the trouble was upon was not damaged, but there were several cars behind that were. The conductor told me that after he left the place where the accident was, the same car uncoupled five or six times again. He finally got an inspector to look it over, and the inspector found that a pin had been put in that was too small, leaving so much play that it caused this knuckle to move back and forth and give way. He put in another pin, and said, "I guess you won't have any further trouble with the car," and he did not. It seems to me that is a case where the inspectors were to blame. I should like to hear what any one has to say about it.

THE VICE-PRESIDENT: Did you trace that back, Mr. Woodward, to see who had passed the inspection on that car?

MR. WOODWARD: Well, it was referred to our car department, and we have not received any report from them.

PROF. ALLEN: Mr. President, a question suggests itself to

me. I don't care to ask specifically about any coupler by name, but I would like to ask if there is a large difference between different makes of couplers in the liability to get out of order. There are two features in relation to that that I have in mind — one is as to the design of the parts, and the other is as to the quality of material put into them. My idea in asking the question is this,— whether it would be possible for railroads, by looking a little more carefully at the make of coupler that they buy, to gain considerably in the freedom from defects. The question is, then, whether there is considerable difference between different makes of couplers (which I do not desire to have mentioned by name) on two points,— the arrangement of details and the quality of the material. I think, perhaps, we might get some good in an answer to those questions.

THE VICE-PRESIDENT: Can Mr. Groobey answer that without calling any names? If he can, he is a gentleman. (Laughter.)

MR. GROOBEY: I have to be very careful. I realize that.

THE VICE-PRESIDENT: This is not an advertising bureau, Mr. Groobey, but we will be glad to get the information requested.

MR. GROOBEY: In regard to the question of strength of couplers, the Master Car Builders' Association has prepared a very elaborate system of testing couplers, which I suppose most of you are familiar with, and which should take care of that feature. The railroad purchasing agent has to decide, or somebody has to decide for him, whether he wants malleable iron or steel. In regard to the different kinds of couplers, I don't think the time is quite ripe to express anything like a decided opinion. The coupler, from all indications, is still going through a transition period. We have got to find out, and will find out eventually, which is the better kind of coupler to use — I mean in a very broad sense.

PROF. ALLEN: If I may interrupt just a moment, what I wanted to get at was not which coupler is the best by description of it, but whether there is a wide difference between the best and the poorest couplers in common use.

MR. GROOBEY: Yes, I think there is.

PROF. ALLEN: That was the point I wished to bring out, and I certainly did not wish to ask a question, the answer to which might prove in any degree embarrassing to the speaker of the evening.

MR. GROOBEY: I think there is a vast difference between couplers in common use today. A question was asked by my friend over here a little while ago as to the number of couplers in use, and as I stated that some four years ago there were about 80, and today I should judge there are about 30, it is fair to assume that 50 of the poorer kinds have disappeared, and in all probability some of the 30, the poorer ones of the 30, will disappear in a few years. At one time a railroad management possibly thought they could save money by buying a poor coupler, but I think they are fast losing that idea. The railroads have to go through a period of costly wrecks to find out just where they stand on this and similar questions.

To corroborate something your President said a little while ago in regard to trains parting, I would like to quote from an accident bulletin of the Commission. This question of trains parting appeared about a year ago to be one of such great importance that we got out some figures. For one year there was a certain number of trains parted reported to the Commission. We thought that we would find the causes, and so we told a man to go through them very carefully and take the railroad company's own explanation as to the cause. We find that there were three deaths from known causes. There were 11 deaths from unknown causes. There were 106 injuries from known causes. There were 280 injuries from unknown causes. The money loss from known causes was $156,000; from unknown causes, $356,000. Here we have reports from the railroads, sworn statements by responsible operating officials, that "We have lost $356,000 this year; we have killed so many people; we have injured so many, and we really cannot tell you how, or why it came about; we don't know."

MR. GRAHAM: Our guest on the left here that went over to see Bunker Hill Monument did not absorb the spirit of Bunker Hill Monument, I am afraid.

THE VICE-PRESIDENT: Mr. Graham, we won't digress from the subject of safety appliances to discuss Bunker Hill Monument

Mr. Graham: I am going to read from this book, "Safety Appliances and Accident Reports."

"It is generally conceded, however, that under the block system collisions are very infrequent as compared with the number occurring under the time-interval system. The block system is now universal on the passenger lines of the railroads of England, Scotland, Ireland, and Wales, and the high degree of safety enjoyed by the passengers on those railroads is well known. In the fifteen months ending March 31, 1902, as appears from the accident records published by the board of trade, not a single passenger was killed in those countries by a train accident."

Now, I just have one thing more to say about the practice of the Britisher. If you will look at a British railway carriage, or a locomotive, you will find that the air-brake train line comes along out under the end, and goes up, and then there is an elbow, and the hose is coupled onto that elbow. When the man goes in to shackle the train, or unshackle the train, he finds the air-hose coupler right at his hand. He does not have to get down. He makes no effort. He simply finds the coupler right there.

In that connection I want to make an explanation. We read in the papers a great deal that there should not be any elbows in the train line of the air-brake, and they recommend bends; all unnecessary. The air will go round the bend just as easily as it goes round the elbow. The practice of dropping the air-hose down on our cars contributes largely to their destruction. Why, here it is. The man says, "Let them pull it apart." It is frozen, he won't bother to get down there. But if he finds something proper up at his hand, he will naturally uncouple it, because it is there to uncouple. If you will go through the railroad shops and watch the air-brake men fitting and coupling up their pipes, you will find that instead of making a nice clean cut on the end of the pipe — a nice clean cut with a tool, they simply work into the pipe, and when they come to take the pipe from the cutting machine they find that the opening in the pipe has been closed up by the tool. Instead of getting the volume of air, 100 per cent., they only get about 60 per cent. So you see there is a fundamental defect in the application, that

is, a detail defect in workmanship. Now, if they put a rosette reamer in the end of that pipe, and take that lip that is there out, they would make the volume of the pipe about 120 per cent. Instead of finding fault with the results of faulty principles, why don't they go to work and cultivate a care for the details, and put the air-hose and the air pipes on the cars, first of all, in a mechanical, clean, up-to-date way, and then put the hose coupling where the train men can get hold of it. Then we would not have such a report as this — $500,000 that we don't know why we have to spend, or, as the chief inspector just said, $350,000 paid out, and we don't know why we had to pay it.

MR. EDDY: Mr. Chairman, the gentleman made a remark that the air would go round a bend just as easily as it would round an elbow. I do not think anyone would dispute him on that point.

MR. GRAHAM: Mr. Eddy, the reason I said that the air would go round a bend as easily as it went round an elbow, was because you could not take offence at it. Now I will reverse it, for the sake of the argument. The air will go round the elbow just as easily as it will go round the bend. It is not a question of how fast you get the air; it is air under pressure, and it is not like a fan blowing the air back through that pipe. There is all this twaddle that men read about bending pipe and avoiding the elbow; if they would simply investigate a little they would find that the air would get there. It is easy, if they will only give the air a chance to go down where it belongs by fixing the pipes right,— removing pipes from elbows, lips from badly cut pipes and see that the lead at the joints does not stop up the free passage of the air.

THE VICE-PRESIDENT: Mr. Leach, don't you want to say something?

MR. H. L. LEACH: Mr. President and Gentlemen, I am connected with a little road down in the wilds of Maine, having practically but one outlet. Most of our freight business is local, cars come to us subject to the inspection of the Maine Central, our inspectors take plenty of time to inspect, and we have very little difficulty with these defects that I hear spoken of.

I am rather new at the car business, but one of the things

that comes to my mind tonight is the uncoupling, or the separating of cars on the road. As a general thing we find these separations occur repeatedly between the same cars. Our train men are careful to report, either by wire or personally, to inspectors at the end of the trip, the cars giving trouble by separating. By giving the matter of worn knuckles and pins special attention we have reduced this trouble more than 50 per cent. during the past year.

There is one other thing that is giving us some trouble during the extremely cold weather, and that is leaks in air-brake hose between the cars. In making up long trains, trains from 30 to 50 cars, with all brakes coupled up, we find that with our 9 1-2 inch pumps we are sometimes delayed anywhere from one half to three quarters of an hour by the inspectors repairing these leaks (separating the hose and putting in new gaskets). I would like to ask if there is anything in the way of a gasket that won't freeze up and will give less trouble than the ordinary gasket that we are using. These two things are the only ones that give us any serious amount of trouble. As I say, the trouble with the knuckles we are overcoming by careful inspection. We try to give our inspectors plenty of time to look over the trains for such defects, and remedy those we find.

THE VICE-PRESIDENT: Mr. Leach, I would like to ask you if you stretch your trains.

MR. H. L. LEACH: In inspecting?

THE VICE-PRESIDENT: Yes.

MR. H. L. LEACH: No. That is a point that I had not thought of. We have been careful, where cars are uncoupled, to inspect them carefully, and measure them. This feature of separating the cars by the method proposed here was a new suggestion to me, which I shall try and put into operation when I get back. I think that is a valuable suggestion. The trouble has been with the inspectors not being able to find all the defective knuckles. I think that is a valuable point.

THE VICE-PRESIDENT: You did not mean by separating the cars to separate them entirely, but to stretch them out?

MR. H. L. LEACH: No, stretch the train so as to measure.

THE VICE-PRESIDENT: That is the only way you can get at it, as it occurs to me.

Mr. FitzGerald, don't you find something in knocking around the yards and shops that it might be well to mention here? Do you, Mr. Merrill?

MR. L. E. MERRILL: Mr. President, only one thing comes to my mind at this time. I notice, coming down from Washington to Chester, that they have retainers and also set up a lot of hand brakes, so they don't seem to put any confidence in the retainers.

THE VICE-PRESIDENT: Perhaps these gentlemen don't appreciate what coming from Washington to Chester means. You and I know all about that, but they don't. From Washington to Chester, gentlemen, is about 13 miles. And what will it average? Eighty feet to the mile.

MR. MERRILL: The average, I think is 80. It runs from 79 to over 82 to the mile.

THE VICE-PRESIDENT: The average, perhaps, won't be 80, but it is a very steep grade, in some places 82 feet to the mile. You had better speak to Mr. Desoe about that.

MR. HAMMETT: Through the Crawford Notch it is at the rate of 116 feet a mile, and they use retainers and a water brake.

THE VICE-PRESIDENT: One hundred and sixteen feet to the mile?

MR. HAMMETT: One hundred and sixteen feet to the mile through the Crawford Notch.

THE VICE-PRESIDENT: Do you use retainers?

MR. HAMMETT; Yes, retainers and a water brake. We cut out the driver brakes because of the danger of slipping the tires, and use the water brake on the engine, and retainers where they may be necessary, generally operating about 75 to 80 per cent. of the cars in the train with retaining valves.

There was one other matter which was suggested to me by what Mr. Lynch said in regard to the trouble in getting gaskets tight. The only way that I have found is, if you have a chance, to do it early. If you postpone it until the engine is on the train you don't get it done without a great deal of delay. We have at one of our most important intermediate terminals a yard testing plant, the whole yard being piped from a large compressor, and we make a practice of charging up all the

trains, going over them, testing them for leakage, and also having the auxiliaries thoroughly charged before the engine sets on. That enables ordinarily a freight engine to set onto a train test the brake, and get away inside of eight to ten or twelve minutes, which is a very material saving, of course.

But the discouraging feature that I have found during the severe weather of the last two months with having air brakes on long trains, trains up to 45 or 58 cars, is the fact that the hose will freeze, that is, become rigid on account of the ice. Then, while the train line may show up very fairly in tightness as long as the train is at rest, just as soon as the coupling is stretched, taking up the slack in the draw bars, the additional distance between the cars due to the compression of the springs opens the hose couplings. There is no flexibility left in the hose, and the stretch has to come in the shape of a rotation of the hose couplings, which loosens them and starts leaks. The remedy for that I confess I don't know yet. It is a serious question, if we are going to have zero weather three months in the year.

MR. G. T. AUCHTER: Mr. President, I would like to ask the gentleman that just spoke how he found the water brake compared to the automatic brake in letting a train down this hill that he spoke of,—down this decline? He said that they cut the driver brake out and used the water brake in its stead. The question that I would like to have him answer, if he will, is how that compares with the holding or retarding power of an automatic character?

MR. GROOBEY: As applied on the driving wheels?

MR. AUCHTER: Yes.

MR. HAMMETT: I don't know that I can say exactly. The results of test of efficiency of water brake through Crawford Notch with 19 x 26 Mogul engine, 160 pounds pressure, engine and tender weighing about 86 tons, showed that water brake could keep under control and bring to a full stop about the same tonnage that the engine was capable of hauling up this grade. The object in cutting out the driver brakes is to prevent heating and loosening the driving wheel tires.

MR. AUCHTER: Then it would be greater?

MR. HAMMETT: I think, if anything, it develops the full motive power.

MR. GROOBEY: Have they a speed limit in connection with the effective use of the water brake?

MR. HAMMETT: Of course there is a speed limit on that, regardless of the water brake,— 12 miles per hour.

MR. GROOBEY: In other words, the water brake might be effective at 15 miles and at 18 miles might be useless?

MR. HAMMETT: It should be borne in mind that 15 miles per hour is the speed limit and not to be exceeded.

The great secret of handling trains — particularly freight — down grades of this description, is to apply braking power early and keep train under control from the start, as the brake power which would be sufficient to control and stop a train moving 10 miles an hour would have but little effect on same train moving 20 miles per hour.

MR. GROOBEY: The question was, I think, what was your idea relative to the efficiency of the water brake?

MR. HAMMETT: Yes.

MR. GROOBEY: As compared with the driver brake.

MR. HAMMETT: I think it is fully as effective.

MR. GROOBEY: Fully as effective?

MR. HAMMETT: Yes, it is fully as effective, I think, and we have found it very satisfactory.

THE CHAIRMAN: How long a grade is that, Mr. Hammett?

MR. HAMMETT: About 13 miles, and it runs about 116 feet to the mile.

MR. GROOBEY: Speaking of grades, Mr. President, the Commission issued a pamphlet on air brake practice a little while ago. They wrote to different parts of the country and got expressions of opinion from people pretty well up on air brake practice, and I will read a paragraph one of the letters contained:

"As you know, the standard breaking percentage of S. P. Co. freight equipment is 90 per cent. of the light weight of the cars, based on 80 pounds train line pressure with Westinghouse equipment."

In the back of this book you will find some profiles which will make clear what I am going to say in regard to the location.

"Upon leaving the Summit, where you will notice the grade

is 116.16 feet per mile, the retainers on all cars are turned up and the train is controlled entirely by air brakes; no hand brakes are set, and it is not the intention that they should be, except in cases of emergency, when the engineer will call for them."

Now there is a severe grade, 116 feet to the mile, and it is never contemplated to use the hand brakes. The retaining valves are presumably in good condition and aid sufficiently to enable the train to be brought down safely. I would like to say, in this connection, that this is a pamphlet that I think ought to be in the hands of all the railroad people.

THE VICE-PRESIDENT: Isn't that the one that was sent to the railroad officials recently?

MR. GROOBEY: I don't know. To some, yes. Has the Club got it?

THE SECRETARY: Yes.

MR. GROOBEY: Have all the Club members copies?

THE SECRETARY: No.

MR GROOBEY: Well, each member of the Club can get one. We would like to send him one.

THE VICE-PRESIDENT: Doesn't it say something in there, Mr. Groobey, about doing away with the water brake?

MR. GROOBEY: No, not there.

PROF. LANZA: I should like to ask Mr. Groobey to what extent he has found accidents due to moisture in the air freezing.

THE VICE-PRESIDENT: In the train line?

PROF. LANZA: Yes.

MR. GROOBEY: Our inspection is of visible parts, as I said, and the moisture, I am afraid, would have to be considered invisible, although there is a lot of it,—there is no question about that. It seems to me I have heard it stated by some air-brake people that the use of the small pump is perhaps a prolific cause of moisture in the air. It is partially responsible for the hose freezing. The moisture gets into the hose and it is then ready to freeze. It is a subject that would well repay investigation.

PROF. LANZA: You have no statistics?

MR. GROOBEY: No, we have never gone into it in that way.

MR. H. L. LEACH: Replying to Mr. Lanza, I would say that we have had pretty cold weather down in Maine this winter, and I have not heard of a single case of freezing of the train line to affect the operation of the brakes.

THE VICE-PRESIDENT: It is getting late, gentlemen. I would like to ask Mr. Groobey if he has anything to say in closing.

MR. GROOBEY: Nothing beyond this, Mr. President and gentlemen, that we are aiming to make our inspection of practical use, and we need your co-operation and assistance. A year ago, when we sent this report to your Club, it was with the expectation that you would discuss it and find fault with it. We are not perfect by a long way, and we want your assistance and criticism in helping to make ourselves more perfect, to make our work better. We want to be in a position to come to you and say that our investigation has disclosed the fact that here is a weak point, here is a weak spot, something should be done — leaving it to your knowledge and experience to supply the remedy. Our inspection is going to be conducted along those lines, with the exception of the feature I spoke of earlier in the evening, the institution of some suits by the Commission, which I am happy to say has had a very good effect. It is a very unpleasant duty for the Commission to perform, and they would prefer to do little of it, if the railroads will only get together and consider questions of detail. I believe that few realize that something which costs only a fraction of a cent, perhaps, is going to make any serious trouble; but it does. It leads up to casualties, it grows and spreads, and you cannot tell what is going to result. It is these little things that we want to call your attention to, and we want your co-operation in bringing about improved conditions in this way.

I am very much obliged to you, gentlemen. (Applause.)

PROF. LANZA: I move that a vote of thanks be tendered to Mr. Groobey and his companions for the interesting talk that we have had this evening.

(The motion was seconded.)

THE VICE-PRESIDENT: It has been moved and seconded that a vote of thanks be extended to Mr. Groobey and his inspectors for coming here this evening and talking to us on the Safety Appliance Act. I am sure it has been very agreeable and instructive to us all.

(The motion was adopted unanimously.)

THE VICE-PRESIDENT: If there are no further remarks the subject is closed. The subject for the March meeting, which is to be our annual meeting, is Steam Turbines. I understand there is to be a paper, probably by a representative of the Westinghouse Company, and possibly the General Electric. The Secretary has an announcement to make.

THE SECRETARY: It is briefly this, that before we meet again you will all receive your bills for the annual dues. The Secretary will be very glad to receive responses from as many members as possible before the annual meeting, as it will help him, and you will be sure that you get the receipts back to show that the money is paid.

THE VICE-PRESIDENT: I would announce, gentlemen, that the usual side-show in the other room is to take place in a very few minutes, that is, as soon as some gentleman will move to adjourn.

(Adjourned on motion of Mr. Baker.)

New England Railroad Club

March 8, 1904.

SUBJECT FOR DISCUSSION:

THE FITNESS OF THE STEAM TURBINE FOR HEAVY POWER SERVICE.

Paper by Mr. J. R. BIBBINS.

E. L. JANES, SECRETARY, SOUTH TERMINAL STATION, BOSTON, MASS.

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NEW ENGLAND RAILROAD CLUB.

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Gen. Manager and Treas., Hunt-Spiller Mfg. Co.

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C. N. WOODWARD,
Div. Supt., N.Y.N.H.& H.R.R.

Treasurer.
C. W. SHERBURNE,
53 Oliver Street, Boston.

Secretary.
EDWARD L. JANES, *B. & A. R.R.*, Back Bay Post-Office, Boston.

Finance Committee.
WALTER B. LEACH, B. M. JONES, HENRY BARTLETT.

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CHARLES F. BAKER, President	" 1902, " 1903.
F. W. DEAN, President	" 1903, " 1904.

The regular meetings of this Club are held at Pierce Hall, Copley Square, corner of Dartmouth Street and Huntington Avenue, Boston, on second Tuesday of each month, excepting June, July, August and September.

NEW ENGLAND RAILROAD CLUB

Published Monthly, except June, July, August and September,
by the New England Railroad Club.

E. L. JANES, SECRETARY, SOUTH TERMINAL STATION, BOSTON, MASS.

$1.00 A YEAR. *Boston, March 8, 1904.* 15C. A COPY.

THE ANNUAL MEETING of the New England Railroad Club was held at Pierce Hall, Copley Square, Boston, Tuesday evening, March 8, 1904, at 8 P. M., President F. W. Dean presiding.

The following members registered :—

Adams, T. W.	Cowden, M. P.	Greenwood, H. A.
Adams, W. H.	Davenport, Frank C.	Hayward, Josiah P.
Aldcorn, Thomas	Dean, F. W.	Henry, Clement M.
Allen, C. Frank	Deane, J. M.	Hibbard, L. J.
Armstrong, C. R.	Desoe, A. J.	Hibbard, L. G.
Averill, A. B.	Desoe, E. G.	Hindle, Wm.
Bailey, Charles A.	Dietz, G. A.	Janes, A. P.
Baker, C. F.	Dodge, J. P.	Jewett, H. F.
Banks, W. H.	Doherty, Edw. J.	Kanaly, M. E.
Barbey, F. A.	Doran, S. P.	Keay, H. O.
Bartholomew, W. S.	Ewart, John	Keeler, J. S.
Berwick, Robert	Fiske, Howard C.	Lanza, G.
Bigelow, C. H.	FitzGerald, J. M.	Leach, W. B.
Braman, S. N.	Flannery, John	Lindall, John
Cahan, F. D.	Gardner, Henry	Lindley, R. M.
Cain, P. E.	Gehman, G. W.	Lord, G. W.
Chaffee, E. F.	Goodwin, C. E.	Lovett, Chas. C.
Chamberlain, H. M.	Graff, S. D.	Manning, J. P.
Chase, R. G.	Graham, John H.	Marden, J. E.
Copp, Chas. E.	Graves, C. W.	Martin, G. W.

Maynard, H.	Pickford, Samuel	Steward, H. M.
McCombs, Henry W.	Pierce, C. C.	Swett, G. B.
Miller, E. T.	Pomeroy, L. R.	Thayer, Albert
Mills, C. S.	Post, C. J.	Towle, J. M.
Muldoon, J. F.	Potter, E. E.	Twombly, F. M.
Murdock, J. C.	Purves, T. B., Jr.	Vorck, F. W.
Nesdell, F. F.	Rice, Edmund	Webster, George S.
Norton, A. O.	Robertson, W. J.	Wetherbee, F.
Olson, G. A.	Sheehan, P. J.	Whall, F. R.
Park, W. R.	Smith, C. B.	Wilson, C. G.
Patten, J. W.	Smith, S. L.	Woods, H. T.
Patterson, S. F.	Starbuck, G. F.	

President Dean: Gentlemen, if you will please come to order, we will begin the exercises of the evening. The first matter in the order of business is the approval of the minutes of the last meeting. They will stand approved unless objection is made by some person.

The next matter in the order of business is Reports of Committees. There is a report to be made by the Nominating Committee tonight, and I believe that is the only one. That report will be read by Mr. Bartholomew.

Mr. Bartholomew: Mr. Kolseth, Chairman of the Committee, is ill, and I will read the report.

New England Railroad Club, Boston, Mass.:—

Gentlemen: The Nominating Committee, appointed by President F. W. Dean, met at the office of the Chairman, Mr. Henry S. Kolseth, 639 Exchange Building, Monday, March 7, at 10.30 A. M., the following members of the Committee being present:— Mr. C. H. Wiggin, Mr. J. T. Boyd, Mr. J. M. FitzGerald,— and owing to the illness of Mr. Kolseth, Mr. W. S. Bartholomew took his place and acted as Chairman.

The Nominating Committee at this meeting had before it the duty of nominating candidates for President, Vice-President, Treasurer, Finance Committee of three members (including the President), and Executive Committee of ten members (including the President)

The Committee takes pleasure in presenting the following list of names for these offices: — President, Walter B. Leach, Gen'l Mgr. and Treas. Hunt-Spiller Manufacturing Company, Boston, Mass.; Vice-President, C. N. Woodward, Div. Supt. New York, New Haven & Hartford Railroad, Boston, Mass.; Treasurer, C. W. Sherburne, 53 Oliver Street, Boston, Mass.; Finance Committee, Chairman, Walter B. Leach; B. M. Jones, 159 Devonshire Street, Boston, Mass.; Henry Bartlett, S. M. P., Boston & Maine Railroad, Boston, Mass.; Executive Committee, Chairman, Walter B. Leach; Chas. F. Baker, S. M. P. and M., Boston Elevated, Boston, Mass.; Prof. G. F. Swain, Massachusetts Institute Technology, Boston, Mass.; T. B. Purves, Jr., S. M. P. and R. S., Boston & Albany Railroad, Boston, Mass.; F. B. Smith, Gen'l M. M., New York, New Haven & Hartford Railroad, Allston, Mass.; C. H. Wiggin, Asst. S. M. P., Boston & Maine Railroad, Boston, Mass.; J. W. Marden, Gen'l Foreman Car Dept., Boston & Maine Railroad, Boston, Mass.; T. W. Adams, Foreman Car Dept., New York, New Haven & Hartford Railroad, Boston, Mass.; William G. Bean, Supt. Southern Division, Boston & Maine Railroad, Boston, Mass.; A. J. Fries, M. M., Boston & Albany Railroad, Boston, Mass.

Respectfully submitted,

H. S. Kolseth,
Chas. H. Bigelow,
J. M. FitzGerald,
J. T. Boyd,
C. H. Wiggin,
Nominating Committee.

H. S. Kolseth,
Chairman.

President Dean: Just now the acceptance of this report will be the only matter to be considered, as there is another item later, the Election of Officers. A motion to receive that report can be made and seconded, and voted upon at the present time. Will some member make a motion to accept the report.

Mr. Purves: I move that the report be accepted.

(The motion was adopted.)

PRESIDENT DEAN: The next item is Unfinished Business. Is there any unfinished business, Mr. Secretary?

THE SECRETARY: Nothing in the way of unfinished business.

PRESIDENT DEAN: Next comes New Business. The only new business, I think, is the reading of the names of new members who have been voted upon by the Executive Committee.

The Secretary read the list of newly elected members, as follows: Frederick A. Carr, Chief Clerk Car Department, Boston & Maine Railroad, Boston; Joseph T. Cunningham, Business Sales Agent National Electric Company, New York; Clark Doty, Foreman Sullivan Square Shops, Boston Elevated Railroad, Boston; James Humphreys, Salesman, H. W. Johns-Manville Co., Boston.

PRESIDENT DEAN: These members have been duly qualified and accepted by the Executive Committee.

Tonight being the annual meeting, the reports of the Secretary and Treasurer, etc., should be read. I will ask the Secretary to read the Treasurer's report first.

New England Railroad Club:—

Report of the Treasurer from March 10, 1903, to March 7, 1904:—

1903.	DR.		
March 10.	Cash on hand	$1,480.60	
	Cash received from Secretary:		
	For dues and new members	1,147.00	
	For advertising	3,007.50	
	For Proceedings	397.18	
	For tickets "Ladies' Night"	29.25	
	Boston S. D. & T. Co., interest	33.20	
	CR.		
	Amount paid on approved vouchers:		
	For printing, mailing, stationery, etc		$1,525.52
	For Proceedings		132.30

	For stenographer		242.50
	For Secretary		900.00
	For entertainments........		884.65
	For expense of committees.		118.75
	For rent of hall...........		360.00
	For Society of Railway Club Secretaries		10.00
	For Foster Bros., repairing frame..................		1.50
	Bank collections		1.95
1904. March 7.	Balance on hand		1,917.56
		$6,094.73	$6,094.73

CHARLES W. SHERBURNE,
Treasurer.

PRESIDENT DEAN: This can be very properly followed by the report of the Auditing Committee, which the Secretary will please read.

BOSTON, March 7, 1904.

Mr. President and Members of the New England Railroad Club:—

Your Finance Committee have this day examined the accounts and books of the Treasurer and Secretary, and find them correct.

F. W. DEAN,
B. M. JONES,
E. T. MILLER,
Finance Committee.

PRESIDENT DEAN: The Secretary will now read his own report.

BOSTON, March 8, 1904.

Mr. President and Members of the New England Railroad Club:—

The passing of another year has added one more chapter to the history of the New England Railroad Club, and it is my

pleasure to present to you a report of the Club for this year, which is now left behind us.

We are promised and expect to have presented tonight a very able paper upon a subject I am sure is of interest to us all, and, therefore, I shall occupy but little time with the report, which is required at this time.

In my report of one year ago, I took occasion to refer to our membership, and I am pleased to report a little improvement this year. March 10, 1903, we had enrolled upon our membership record 516 active and 2 honorary members. We have suspended 34 members for nonpayment of dues, agreeable to Article IV. of our By-Laws; 15 have resigned their membership, and we have lost 9 by death during the year.

We have received into our ranks 32 new members (including those names read tonight), which makes 490 names upon our active membership list and 2 upon our honorary page at this meeting.

We should expect, I think, a larger increase of new members the coming year, by virtue of the action taken by the Club at our last regular meeting, when, you will recall, the Article relating to fees and dues was amended, which made the fees $5.00, this to include the dues of first year of membership or to the next annual meeting.

Please bear in mind, however, there is something for the individual member to do to fully accomplish the end desired regarding our membership,— to broaden and increase it materially. The attendance at the meetings the past year has been fair, but not as large as it should have been.

Someone has said this has been an "off year" with the railroad clubs throughout the country. Be that as it may, it is certain sure there is room for further improvement in this direction for our meetings the coming year.

As to the work of the Club, it certainly shows favorably with former years and speaks with commendation for the thorough and conscientious effort on the part of the various officers and committees, which has been made to advance the Club's interests and maintain the high standard of our Proceedings, attained as the result of valuable papers presented by those who are well-known authority upon the subjects discussed.

The social side of our organization has not been neglected, and a Ladies' Night was held January 26, being the second one, at which many of the members with ladies attended, and all enjoyed the entertainment provided.

We would not be unmindful of our advertisers, and desire to take this opportunity to thank them for their co-operation and aid in extending the work of the Club and assure them of our appreciation of their continued good will.

In closing, I wish to acknowledge to the officers and members the kind courtesy and consideration received at their hands, and extend my best wishes for the continued success and welfare of the Club.

Respectfully submitted,

EDW. L. JANES,

Secretary.

PRESIDENT DEAN: What action shall we take in regard to these three reports, those of the Treasurer, the Auditing Committee and the Secretary?

(The reports were accepted and placed on file.)

PRESIDENT DEAN: The next matter on hand is the Election of Officers. You have already heard the recommendations of the Nominating Committee, and you will now decide what you will do with these recommendations. The list of officers, perhaps, had better be read once more, in order to have the names fresh in your minds.

(The Secretary read the list of nominations.)

PRESIDENT DEAN: What action will you take, gentlemen, on these nominations?

MR. MILLER: Mr. President, I move that the Secretary be instructed to cast one ballot for the various officers nominated by the Nominating Committee.

(The motion was seconded and adopted.)

PRESIDENT DEAN: Mr. Secretary, will you please perform your duty in that respect.

THE SECRETARY: The Secretary casts a ballot for officers of the Club agreeable to the list of names presented by the Nominating Committee and as read.

PRESIDENT DEAN: This ends my term of office, and I want

to thank you all for the consideration which you have given to me during the past year, and to say that I have enjoyed the time very much and have had a great many pleasant experiences in it. I think that some meetings of the Club have been very interesting. There has been quite a variety of topics considered, and while it has sometimes seemed as if the topics would be exhausted, they do not seem to have been so far. The Subject Committee has always been able to meet the needs of the Club, and I presume that new topics will constantly occur to each forthcoming Subject Committee, and that the Club will continue to have matters fresh before them always. I wish to thank you once more.

I now take pleasure in introducing to you Mr. Walter B. Leach, General Manager and Treasurer of the Hunt-Spiller Manufacturing Corporation. I present to you Mr. Leach. (Applause.)

(Mr. Leach presiding.)

PRESIDENT LEACH: Gentlemen, I had a word or two that I thought it would be fitting for me to say, and I was afraid if I got up here and began to talk extemporaneously I might say some things that would not be proper to appear in print, so I just scribbled them off and I have them on paper. I will read them; with your consent.

REMARKS BY W. B. LEACH.

Gentlemen of the New England Railroad Club:—

I feel that I would be lacking in appreciation if I failed to thank you for the honor you have conferred upon me tonight by electing me President of this Club. When I say I feel that you have conferred an honor upon me, I do not want you to think that I am saying so because it is proper for me to say something at this time, but because I sincerely feel that it is an honor to be well enough thought of to be elected by the members of this Club to be their presiding officer.

The New England Railroad Club is one of the older of the railroad clubs, and while its membership is not as large as some of the others, still our reputation is such as to put us well up to the top of the list of railroad clubs of this country. This is the result of untiring efforts of our past Presidents and

the support that they have received from the Executive Committees and members.

This brings us to a very pointed and should be to us all a very personal question. Do we want to see this Club improve, do we want it to remain as it is, or will we be satisfied to see it decline? If the latter, we can all rest on our oars and drift with the tide, which will surely take us down the stream. If we are contented to have it remain as it is, we can continue to work as we are working at present; but if we want it to improve, we must all put our shoulder to the wheel and push and keep pushing, for by so doing is our only hope for noticeable improvement.

How many of you have watched the progress of this Club? If you have, and have given it careful consideration, you have doubtless felt that we are not progressing as we should. Please do not consider that I am referring to our strength either as regards our financial condition or our membership, but as to the attendance at the meetings and the interest manifested at them? Why is this? Have we not a membership of representative men? Do we not have instructive and interesting subjects for discussion and a nice lunch for the refreshment of those who attend the meetings? I think you will all answer in the affirmative to each of these questions, and yet I feel that our meetings are not what should be desired.

And I would like to say, gentlemen, from my personal observation, that if the members, individually and collectively, took the interest in the meeting in this room, and worked as hard and made the personal effort that they do when they pass into the room on the side, we would be pretty near perfection. (Applause.)

There is no reason for this,—for our meetings not being what we desire— except that the members do not feel their individual responsibility. Now, what I want to ask is for the members—one and all—to support me and the officers of the Club in an effort to make a decided improvement in our condition. You can do this by your regular attendance at the meetings, and then, when the proper time arrives, enter the discussion, and by so doing assist in making the meeting interesting.

I think it is the duty of every member to consider that his attendance at the meetings is just as much one of his obligations as any other business that he may have. And it should not stop here; he should, before coming to the meeting inform himself as to the subject of the evening, and, if possible, come prepared to contribute to the discussion.

I, of course, appreciate the fact that the railroad men may, on account of circumstances, be unable to attend every meeting, but this would be semi-occasionally. The members as a rule do not, in my opinion, consider it their duty to come, but look at it as an evening's outing, to be indulged in if entirely convenient.

We had a Ladies' Night recently. There was a nice entertainment, dance and lunch. It was well worth, and probably cost twice, what was charged as the price of admission, but it was arranged that the Club stand the loss and let the members get the benefit, and, gentlemen, out of a membership of 500 only about 80 members purchased tickets.

I don't want you to think that we sold but eighty tickets, nor that there were not more than eighty people in this hall. We did sell something over three hundred tickets, and had a good representative audience here, considering the night, but that was not the fault of the members. Remember, only eighty members bought tickets. This to me shows indifference and that the members do not appreciate the importance of feeling a personal responsibility.

This to me shows indifference and that the members do not appreciate the importance of feeling a personal responsibility in the work of the Club.

We would like more assistance from our members who are supply men, and would like them to consider the importance of advertising in our Proceedings. It is, of course, understood that the revenue from this source is our principal means of support. If you do not advertise now, do so at once, and if you now advertise, increase it.

I notice by the Secretary's report that he feels thankful for the support that he has met with this year from the supply men, and I presume I ought to get right in line and say that we are ever so much obliged for everything they have done,

but they should not forget that we have another year to come along.

There is another way that the members can assist, and that is in suggesting subjects for our consideration. I have often heard members complaining that we never have subjects touching on their line of the business. Now it is all right to complain, but it should be done to the proper person; if he will mention it to the chairman of the Subject Committee or to the Secretary or President, I am sure that it will be considered.

Some time ago the Secretary announced that he would be glad to receive subjects for topical discussion, and I doubt very much if the members embraced the opportunity to the extent desired.

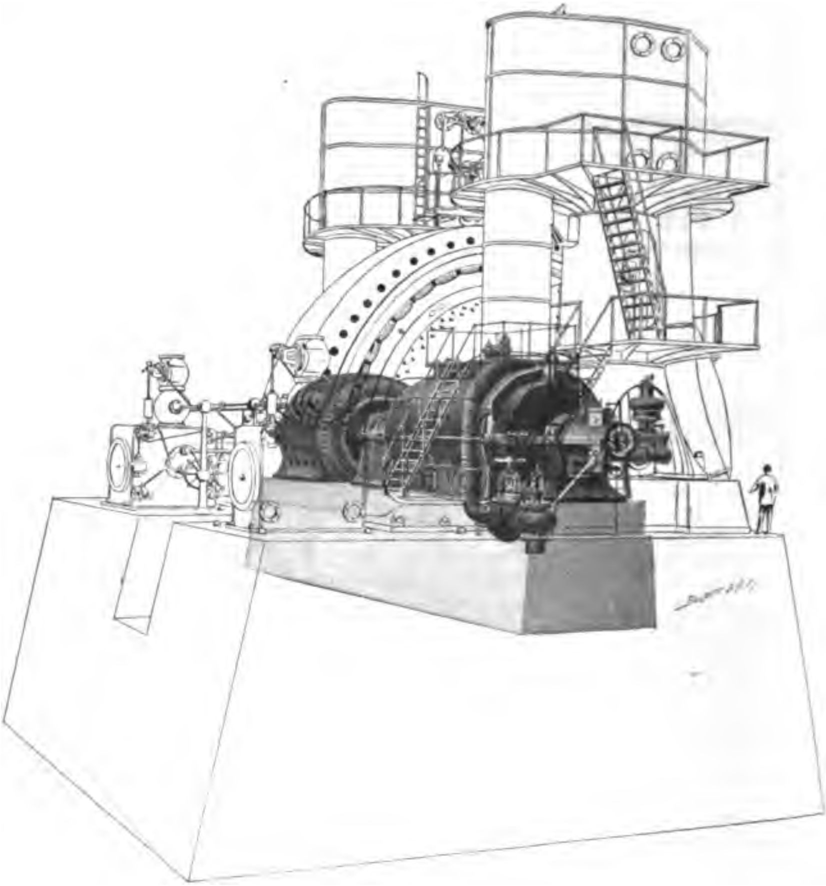
There is another way that we can assist, and that is by having a better acquaintance among ourselves. I know there are members who attend regularly who have a very limited acquaintance here. This is principally due to the fact that they do not make themselves known to others. If you would all make it your business to shake hands with those that you have repeatedly seen here and inquire their names, you would soon be well acquainted and feel at home and have an additional interest in coming.

I think I have taken more of your time than I should, but I had these things to say, and I thought this was the time to say them. Gentlemen, I thank you. (Applause.)

The next order of business is the appointment of committees. There are three committees to be appointed by the chair, the Subject Committee, the Membership Committee, and the Publication Committee. I will make the appointments and announce them at the next meeting.

I know of no other business to come before the Club. Has any member anything for the good of the order?

The subject of the evening, gentlemen, is "The Fitness of the Steam Turbine for Heavy Power Service, with Special Reference to the Westinghouse-Parsons Type." The paper, which is to be illustrated, will be given by Mr. J. R. Bibbins of the Westinghouse Machine Company. Gentlemen, I take pleasure in introducing Mr. Bibbins. (Applause.)



COMPARATIVE SIZE OF 5000 KW. ENGINE AND TURBINE GENERATING UNITS.

THE FITNESS OF THE STEAM TURBINE FOR HEAVY POWER SERVICE.

(With special reference to the Westinghouse-Parsons Type.)

PAPER BY MR. J. R. BIBBINS.

MR. PRESIDENT AND GENTLEMEN:—The subject of this paper was chosen after some thought as to what particular phase of the general subject would prove of greatest interest to you, and, as we are indebted to your courtesy for the opportunity to speak upon the subject nearest our hearts, we hope to be pardoned for giving almost exclusive attention to the parallel flow type, of which the Parsons and licensees are the principal representatives. The author would also express his thanks to your Society for perfecting arrangements to illustrate the paper by the use of stereopticon views.

There are at present few subjects productive of more discussion in the world of engineering than the comparative merits of gas engines, steam engines, and steam turbines. These, together with the hydraulic turbine, constitute our entire stock of prime movers; each has more or less clearly defined fields of usefulness, which, however, unfortunately overlap. Leaving out of consideration the limited application of the water turbine, the battle royal is on in earnest between the gas engine, the steam turbine and the reciprocating steam engine which for nearly two centuries has held undisputed sway in the field of power production on a large scale.

In recent discussions before technical societies on the general subject in hand, the keynote of thought and criticism has been the reliability and fitness of the steam turbine for the general and specific duties for which it is advocated by its supporters. Operative efficiency has for the moment been accorded a position of secondary importance. This is natural and pertinent. However efficient a prime mover, if, through general complications, doubt exists as to its ability to perform its duties con-

tinuously, the cautious engineer feels compelled to supersede it by "the good old reliable" even though less efficient engine.

A glance at the present extent of the turbine industry reveals a development that at once carries conviction as to the merits of this ideal form of motor. The industry practically originated with the Hon. Charles A. Parsons, who brought out his first experimental machine in 1884. Within four years, turbines aggregating 4,000 horsepower capacity, all of the non-condensing type, were at work. By 1902, eight hundred turbines had been sold, aggregating about 200,000 horsepower, the largest machine being of 3,000 horsepower nominal rated capacity. Marine work was begun in 1894, and, in spite of tremendous opposition from engine builders, Mr. Parsons, early in 1903, had succeeded in establishing his turbine to the extent of 83,000 horsepower, which has probably been increased to nearly 100,000 up to the present time.

In 1895, the manufacturing rights of the Parsons turbine were acquired by the Westinghouse Machine Company, who commercially introduced their product in 1898. During the succeeding period nearly 25,000 horsepower have been put in operation, and an aggregate of 200,000 horsepower have been sold, in sizes ranging from 500 to 7,500 horsepower. On the Continent, the well-known electrical firm of Brown, Boveri & Company of Baden also acquired the Parsons rights, and up to 1903 had contracted for sixty-eight units aggregating 63,000 horsepower, or an average per machine of nearly 1,000 horsepower, the largest machine being of 3,000 horsepower capacity.

Thus the progress of the Parsons type of steam turbine aggregated, at the end of 1903, 525,000 horsepower in round numbers, including marine equipments.

Outside of marine work, the particular field of usefulness for the turbine is in the power plant, where it forms the ideal prime mover for the driving of electrical generators, and the future of the turbine will undoubtedly be closely associated with that of electricity in its special application to power distribution by alternating currents at high potential, for electric lighting systems, industrial works and traction systems, both heavy and high speed. In the rapidly expanding field of electric traction, it is of interest to observe that the steam turbine has been

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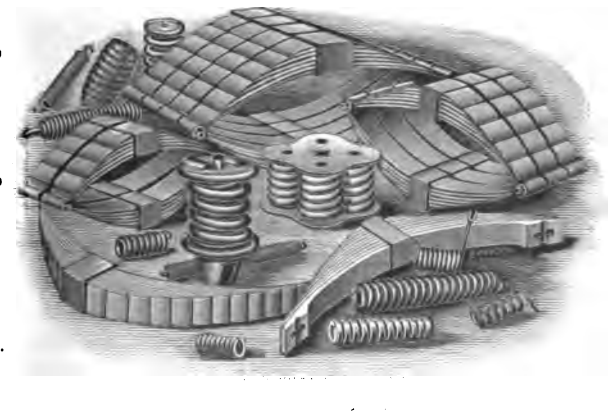

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already adopted by some of the most modern and heavily financed corporations in existence at the present time. The most prominent of these may be mentioned:

Interborough Rapid Transit Company, New York. Turbines were introduced for lighting the Rapid Transit Subway, but the power house, originally laid out for reciprocating engine units, will be extended with turbine units, the first unit of which has just been contracted for.

Pennsylvania, New York and Long Island Railroad. In the original plans for the power equipment for the immense terminal enterprise, turbines were given consideration and will furnish power exclusively for hauling all passenger trains from the Hackensack Meadows to New York and Long Island.

Philadelphia Rapid Transit Company. Turbines were adopted in the original design for the power house, and will furnish power exclusively to the subway traction system now under construction.

Metropolitan District Railway, London. The power house was similarly laid out for turbine units which are now being built and installed.

Metropolitan Railway, London. New power house similarly laid out for two turbines.

The Brooklyn Heights Railway Company. Turbines have been adopted for further extensions in the power equipment.

In these plants Westinghouse-Parsons turbines of 3,500 to 5,500 kilowatts, or 7,500 horsepower capacity, will be employed. These six installations aggregate 92,000 kilowatts, or 125,000 horsepower, in nineteen units, thus averaging 6,600 horsepower per unit, while the ultimate capacity of the stations will be nearly twice this amount.

The imminence of steam turbine introduction in the American navy forms an item of additional interest to the disciple of progress. With these facts in view it is at once apparent that the presence of this type of motor already constitutes a factor of immense importance in commercial power development, and one that cannot be ignored.

General Principles:—Up to the time of its introduction by Parsons and DeLaval, the utilization of steam for power work had been entirely through direct expansion in the cylinder of the reciprocating engine. The idea of employing the kinetic

energy of a steam jet was not new, but not until demonstrated by Zeuner was the fact fully appreciated that the energy available in a properly directed steam jet is equal to that to be derived from direct expansion in a piston engine, provided that in both cases the steam expanded through the same range of temperature and pressure. This is, of course, a purely theoretical relation, and is only approximated in practice.

In many respects the steam turbine presents a direct parallel to the hydraulic turbine.* Both employ nozzles or guide vanes to direct the moving fluid against rotating vanes mounted upon the periphery of a supporting spider, these vanes being in such form and position as to convert the greatest percentage of the inherent energy of the fluid into useful torque on the shaft. A radical difference, however, between the two forms of turbines lies in the characteristics of their respective working fluids, one being expansive and the other practically non-expansive. In the steam turbine, two energy conversions take place: first, heat energy is expended in expansion and in producing high steam velocity; second, kinetic energy of the steam jet is transformed into useful work through impulse, reaction, or both. The second conversion alone presents a parallel case to that of the hydraulic turbine. Water, during its discharge through a turbine, remains at practically constant volume, but that of steam increases rapidly in expanding from boiler to condenser pressure; for instance, one cubic foot of saturated steam at 200 pounds pressure expands 154 times to 28 inches vacuum and 340 times to 29 inches vacuum. Further, by reason of the lower density of steam, high velocities must be dealt with in order to obtain best theoretical efficiency.†

The general principles of design of the hydraulic turbine apply to the steam turbine as well. Thus all sufraces coming in contact with the working fluid should be so designe das to minimize surface friction and avoid eddy currents. The jet should be so guided as to meet the vanes without shock and

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* All prime movers which operate on the principle of the conversion of kinetic energy of a fluid jet directly into rotation, either by impact or reaction, or by both, may be broadly classed as turbines.

† This point may be brought out by the following comparison: One pound of steam discharging through a nozzle from 165 pounds pressure to 1 pound absolute, or 28 inches vacuum, will, theoretically, develop about 250,000 foot pounds of energy. One pound of water on the other hand, will develop but 379 foot pounds under the same conditions. The velocity of efflux of the water jet will be about 156 feet per second, and that of the steam jet over 4,000 feet per second, or 50 miles per minute.

no sharp angular deflections should occur during its change of direction. In the impulse turbine, of which the Pelton and

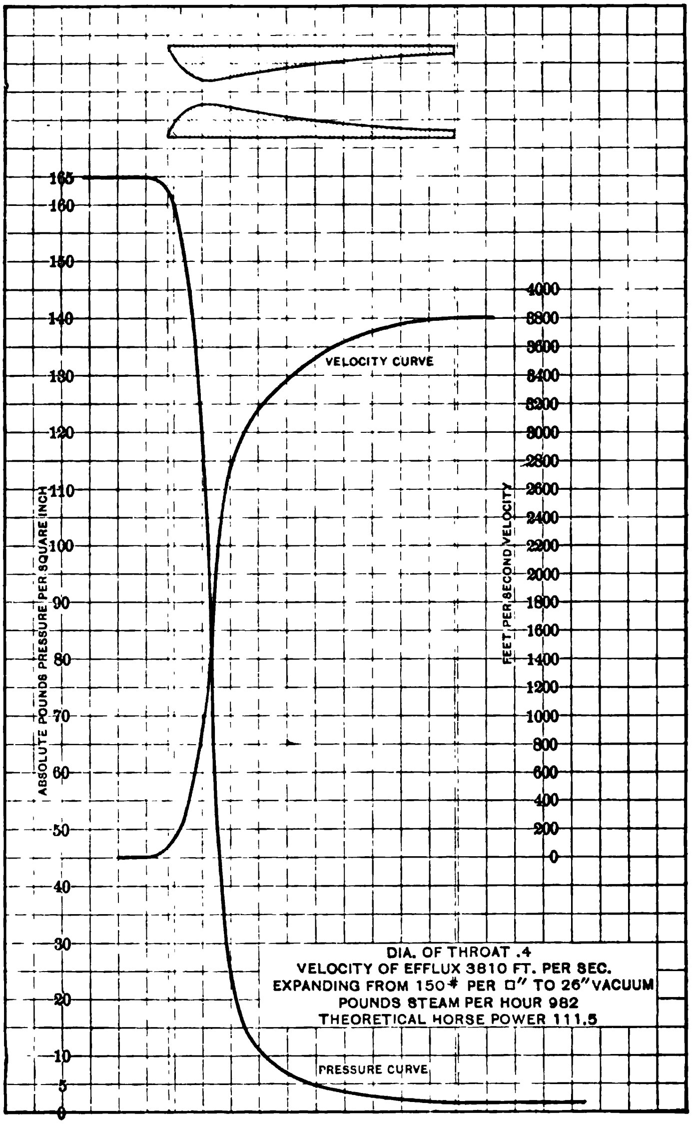

Fig. 1.—PRESSURE AND VELOCITY CURVES OF STEAM NOZZLE.

DeLaval are representative, the proper velocity of vanes for maximum efficiency should be half that of the issuing jet. In

the reaction type it should be equal to that of the deflected jet. Thus, in the DeLaval steam turbine, the bucket speed should be about 2,000 feet per second for best efficiency under high vacuum. This enormous speed, however, imposes such severe stresses in the metal of the disc that in practice lower speeds are, of necessity, employed.*

To the Swedish engineer, DeLaval, belongs the credit of introducing the ingenious divergent nozzle as a means of obtaining full expansion of steam in suitable form for projecting against a rotating vane wheel. Its action is well shown by the

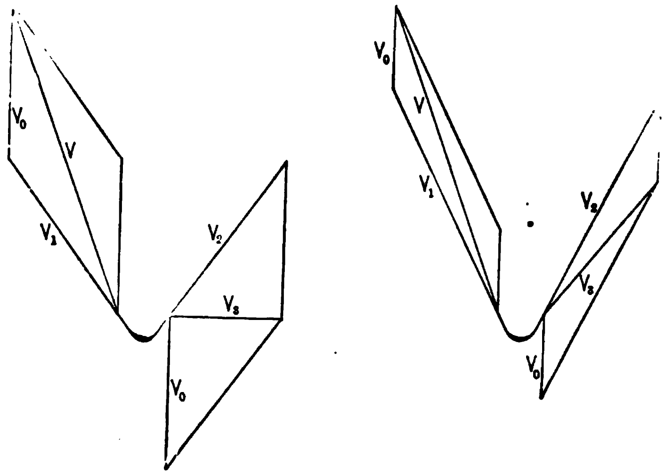

Fig. 2.—VELOCITY DIAGRAM.

curves, Fig. 1. As the increasing diameter of the nozzle provides room for further expansion, the jet velocity increases and the pressure and temperature fall through the entire range from boiler to condenser. This occurs within a length of a few inches. The expansion is nearly adiabatic and the temperature at each section of the nozzle remains approximately constant.

The action of an ideal steam jet may be shown by the velocity diagram, Fig. 2, in which case the bucket speed is assumed to be half that of the jet. Steam entering in the direction V gives up its energy, first by impact and then by reaction. V_0 represents the absolute velocity of the vane. V_1 and V_2 represent

*In a 30 h.p. turbine which operates at a speed of 20,000 r.p.m. the radial stresses at the rim amount to 23,000 pounds per square inch. Anderssen-Trans. Inst. Eng. & Shipbuilders, Scotland, 1903.

the relative velocity and direction of the jet. V and V_3 represent the absolute velocity and direction of the jet. The steam, therefore, leaves parallel to the shaft, with its power for producing torque entirely abstracted. If it is necessary to employ a bucket speed lower than the theoretical, the exhaust will not discharge along V_3 but will be deflected upward along an angle which is dependent upon the difference between the true and actual speeds, as in the diagram at the right. Fig. 2.

All turbines make use of this principle in one form or another. The DeLaval construction still retains the high disc speed, which ranges from 10,000 to 30,000 r.p.m., depending upon the size. This necessitates a 10 to 1 reduction gear. Parsons, however, from the very first aimed at speeds sufficiently low to provide for direct connection of the turbine to generating and

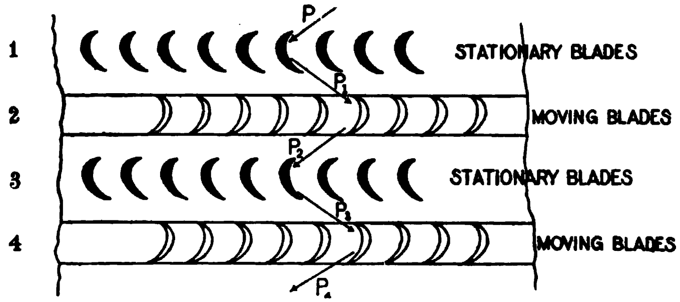

Fig. 3.—ARRANGEMENT OF VANES.

other machinery without the use of gearing. This result he secured through the use of the multiple expansion, or stage principle, an invention fully as remarkable in its effect upon the industry as the brilliant inventions of the divergent nozzle and flexible shaft by DeLaval. He instituted the arrangement of vanes shown in Fig. 3 which replaces the expanding nozzle. It is evident from Fig. 2 (right) that if the steam discharge along V_2 were redirected by stationary guide vanes along a path parallel to V_1, whatever velocity energy remained might be abstracted by a second vane wheel arranged as in Fig. 3. This leads to an extension of the process *ad infinitum*, resulting in a fractional abstraction of energy pressure and velocity by a number of vane wheels mounted in series upon a single shaft. This principle distinguishes the Parsons or parallel flow turbine

from the simple impulse type, and secures commercial speeds of rotation without the use of reduction gearing. No nozzles are employed, as the functions of the nozzle are performed by the vanes themselves. Steam at initial pressure P, in passing through ring 1 of guide blades, expands to pressure P_1 through a fraction of the total range proportional to the number of stages; with correspondingly increased velocity it enters the ring 2 of moving blades where it again expands to pressure P_2. The total dynamic effect on ring 2 of moving blades is due to two independent factors (1) impact and (2) reaction of steam which is impelled simply by the difference in pressure $P_1—P_2$ on opposite sides of the vane wheel. Ring 3 of stationary blades redirects the steam jets to their original direction and the process is repeated to the end of the series, the pressure gradually lowering to that of the condenser but the velocity alternately increasing and decreasing with each ring of blades. The expansion previously shown in the form of curves for the nozzle is thus carried out with steam velocities varying from 150 to 600 feet per second, at different points in the series, and running speeds have thus been reduced to a fraction of those of the impulse type—*viz.:* 750 to 3,600 r.p.m. according to the size. This reduction in steam velocity is one of the most important sources of high economy in the Parsons type, on account of the reduction of the fluid friction, and therefore the proportion of lost work to useful work.

Other means of arriving at low running speeds have been tried in turbines of late design; (*a*) compounding the simple impulse turbine, and (*b*) employing large wheel diameters. In (*a*) each stage is fitted with a set of nozzles, in which but part of the total expansion is carried out. The nozzles, however, serve directly but a small portion of the wheel circumference. Thus, a considerable portion of the peripheries of the bucket wheels, frequently as much as two-thirds, are idle and are simply active in increasing the lost work, due to fluid friction of large areas moving at relatively high speeds in a dense atmosphere. For this reason, in some forms of impulse turbines, it is extremely advantageous to employ as high a vacuum as possible. This reduces the density of the atmosphere in which the discs and buckets revolve, and consequently the resulting fluid

friction.* In the Parsons construction, the entire periphery of the turbine wheels is active in producing torque, and as the steam is confined to a comparatively small area around the periphery of the turbine, the fluid friction, resulting from causes above noted, is avoided. Tests given below show that the results from turbines operating under lower vacua are not less excellent, relatively, than those operating under high vacua.

CONSTRUCTION: Turning now to the general construction of the Westinghouse-Parsons turbine, a section of which is shown in Fig. 4, we observe three essential elements: the *rotor*,

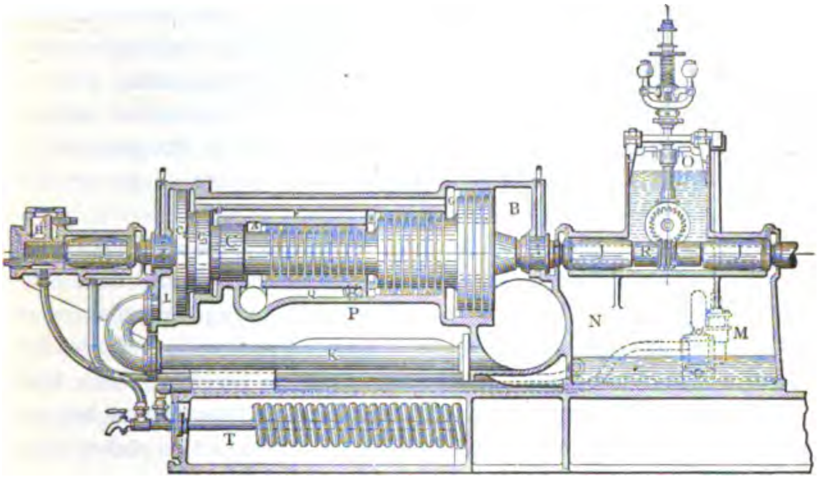

Fig. 4.—SECTION OF A TYPICAL TURBINE.

the *stator*, and the *balancing pistons*. The rotor consists of a cylinder of three or more drums of increasing diameter, upon the periphery of each of which are mounted numerous rings of radial vanes. The stator comprises a split casing of interior proportions conforming to those of the rotating cylinder. The interior walls of the casing are studded with rows of stationary radial blades corresponding to those on the moving cylinder but assembled with a reverse pitch. High pressure steam enters the turbine through the annular orifice *A*, expanding to the

* Dr. Stodola in his excellent work on "Die Dampf Turbine" quotes a test by Lewici upon a 30 horsepower DeLaval turbine. The resistance of the disc with dry saturated steam at atmosphere was 3.3 horsepower or 11 per cent. friction, and at 19.6 inches vacuum but 5 per cent. With 300 deg. C. superheat the resistance at atmosphere was 6.25 per cent., and at the same vacuum 2 per cent. Higher vacua would have proven still more beneficial.

right through the several stages to the exhaust *B*. The rotating balance pistons, designated by the letter *C*, are equal in number to the number of drums, and each piston is of such diameter that the axial thrust resulting from the impact of the steam upon the blades of any drum is exactly balanced by corresponding pressure against the pistons. These pressures are at all times equalized by means of the ports *F* and the pipe *K*. It will be observed that the balancing of the rotating element is entirely independent of the absolute or relative pressures in the various stages, so that the adjustment bearing *H* is entirely relieved of axial thrusts. Its only function is to preserve the proper mechanical clearances between moving and stationary blades. The balance pistons revolve within the casing with a close fit but without mechanical friction. Leakage of steam past the piston is prevented by deep grooves in the periphery, which interpose so devious a path for the steam as to render loss from this source quite inappreciable.

In this form of turbine the area for the expansion of steam is secured by gradually increasing the annular volume between rotor and stator, which may be regarded as a single annular nozzle. Starting from *A*, blades of increasing length are employed in the first drum until a mechanical limit is reached, when the diameter is abruptly increased and a second progression begun with shorter blades, these again lengthening to the end of the second drum. If pressure gauges and thermometers were inserted at regular intervals, in the several expansion stages, these instruments would indicate an approximately uniform gradation of pressure and temperature from inlet *A* to exhaust *B*, thus indicating graphically the conversion of heat into work; and it is a noteworthy point that the temperature of the casing falls within a distance of three or four feet, from that corresponding to the boiler pressure to that of condenser. With 150 pounds of steam, 100 degrees superheat, and 27 inches vacuum, this range is approximately 350 degrees Fahrenheit, or approximately 10 degrees per inch length.

It is fortunate that these local temperature conditions remain constant during operation. In a piston engine, alternate condensation and re-evaporation takes place with each repetition of the expansion cycle. In the turbine approximately adiabatic

expansion is realized, as no heat is taken in or given out, and the temperature of the casing remains approximately equal to that of the steam in each expansion stage.

The advantages of high ratios of expansion may also be realized without largely increased cost or complexity. In the piston engine the use of three or four expansion stages is accompanied by very bulky and complex construction, and it is found that an attempt to expand below 5 pounds absolute may readily result in negative economy due to increased friction and thermal losses, which more than counteract the increase in indicated economy. In the case of the turbine, the extra volume required for high expansion ratios is readily provided without excessive bulk and without introducing friction comparable with that of the piston engine. As a result, the "toe" of the indicator diagram, which is not available for useful work in the piston engine, is made use of in the turbine, with a proportionate increase in net economy. Vacua as high as 28 1-2 inches of mercury referred to 30 inches barometer are therefore permissible and, as will be shown later, are warranted by the increased economy obtained.

The most vital parts of the turbine are the steam vanes or blades, as upon their precise curvature and arrangement depends in a large measure the economy of the machine. The form of blade used in the Westinghouse-Parsons turbine is the result of both theory and extensive experiment. They are usually made of a special bronze, cold drawn, of tensile strength averaging 75,000 to 80,000 pounds per square inch, with 20 per cent. to 30 per cent. elongation. This material is drawn out into long strips and the blades are then sawed off to proper lengths. They are assembled by a caulking process in grooves turned in the steam surfaces of rotor and stator. This method has proven so effective that the force required to pull out the blades exceeds the elastic limit of the material. It also greatly facilitates repairs, should such ever prove necessary. In direct contrast to this simple form of blade-mount is that employing milled buckets on the periphery of the turbine wheels. Accidents are of course unavoidable in the most perfect mechanisms, but should such occur in the Parsons form of turbine, the damage is generally quite local, a few rows of blades only being

affected.* Fig. 5 shows the method of opening a 400 k.w. turbine for inspection.

In comparison with the ultimate strength of the blades, the pressure exerted upon them from the impact of steam is minute, varying from .055 to .065 of a pound in a 400 k.w. turbine, which is obviously but a small percentage of their bending strength. The very multiplicity of blades employed in this type therefore results in great inherent strength of construction.

Running clearances, both axial and radial, are ample to insure freedom of motion in all directions. Flexure or sagging of the shaft at the center is prevented by rigid quill construction and the danger from adjacent rows of blades coming in contact is practically impossible on account of the large clearances employed, which vary from 1-8 inch to 3-4 inch according to the size of the blades. These clearances are maintained by the adjustment blocks.

The impression seems to be more or less general, that large axial clearances in the Parsons turbine are necessary to prevent contact of moving and stationary blades, due to unequal expansion of rotor and stator. This is by no means the case. Both parts of the turbine are approximately at the same temperature as that of the steam passing through the machine, and both expand and contract as a unit, thus preserving the original relation between moving and stationary blades. The stator, or casing, is anchored to the bed-plate at the exhaust end by heavy bolts, while the steam end rests upon a foot sliding between machined ways. The entire body of metal is thus free to move according to the temperature of the steam used. This is not the case in some forms of compound impulse turbines where differential expansion of shaft and casing is encountered, thus aggravating the already troublesome problem of preserving small axial clearances.

Too much importance is also usually attached to the point of peripheral leakage, and the fact has generally become lost

* A case in point occurred in one of the installations illustrated further on. An expanding exhaust pipe which had been too firmly anchored at the lower end occasioned sufficient distortion of the turbine casing to destroy a dozen rings of blades. The turbine was immediately shut down, the casing opened and the broken blades cleared away. It was then again put under steam and continued in full load service during the day without trouble or apparent effect on capacity. During the following nights, after extra blading had arrived from the factory, the machine was again opened and the damaged rows replaced. The accident kept the turbine out of service for about three hours.

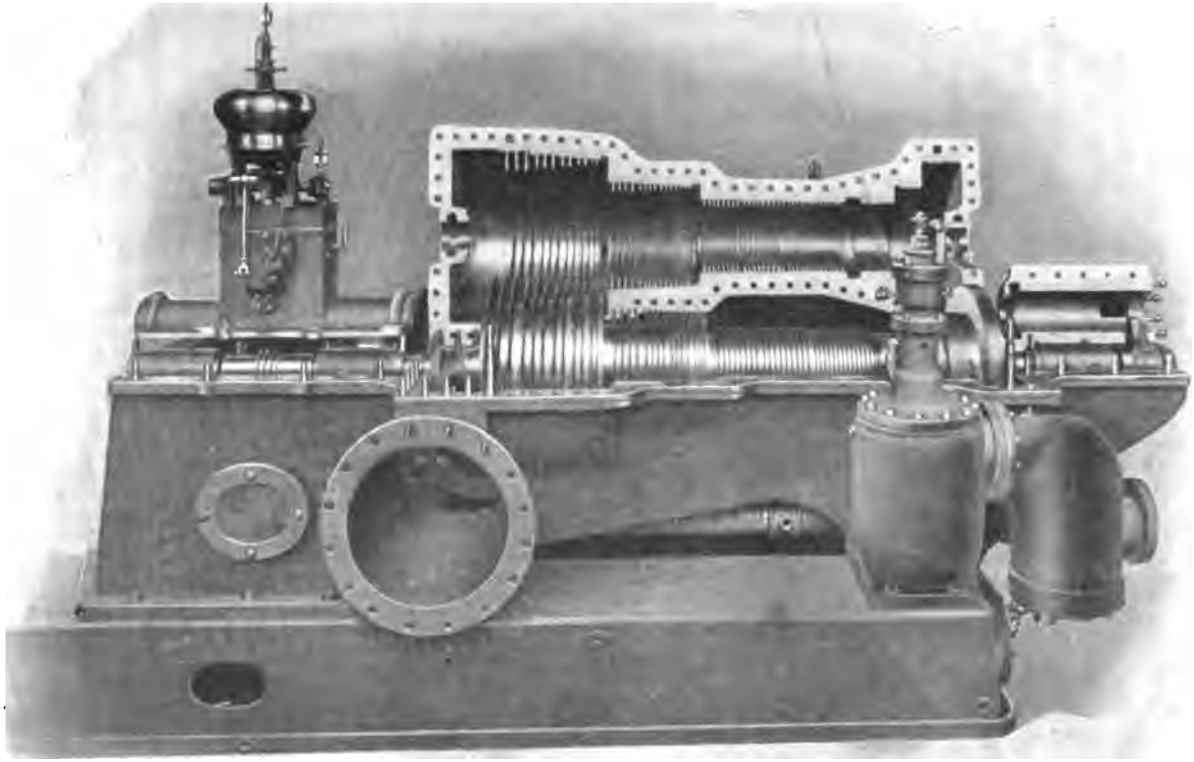

Fig. 5.— TURBINE OPENED UP FOR INSPECTION.

sight of that whatever leakage occurs does not entirely represent lost work. This leakage steam passes into the succeeding stages where it does useful work by giving up its heat to the working steam, which is at a lower temperature, due to expansion. On account of the high pressure employed, the greatest leakage would naturally occur at the beginning of the expansion, as in a machine of given size the radial clearances are constant. By the time, however, that the lower stages of the turbine have been reached, the total volume of steam has

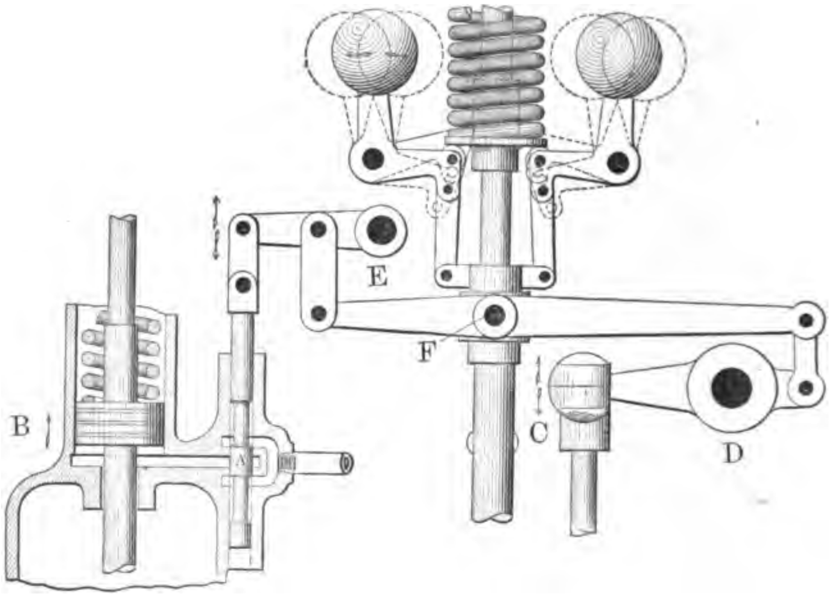

Fig. 6.—ARRANGEMENT OF GOVERNOR MECHANISM.

become so great compared with the clearance area that the leakage steam becomes a comparatively unimportant factor.

The method of regulating the speed of the turbine comprises two unique features; one in mechanism, the other in theory. Fig. 6 shows diagrammatically the arrangement of the governor mechanism. The governor is of the purely centrifugal type with bell crank levers swung on knife edges and resisted by a spiral spring, the pressure of which may be adjusted by the knurled tension nut. The spring part of the mechanism is mounted between ball bearings and may be brought to rest

while the turbine is running. By increasing the spring tension the speed of the turbine is increased, and vice versa. This affords a means of synchronizing two alternating current generators for parallel operation and for accurately distributing the load after synchronizing. The main admission valve is actuated by an auxiliary piston *B*, which is in turn moved by the pilot valve *A* through the agency of high pressure steam admitted through the ports shown. *D* and *E* are fixed points, *F* a floating fulcrum, the position of which is determined by the position of the governor balls. Reciprocating motion from an eccentric driven by a shaft is transmitted to the point *C*. This

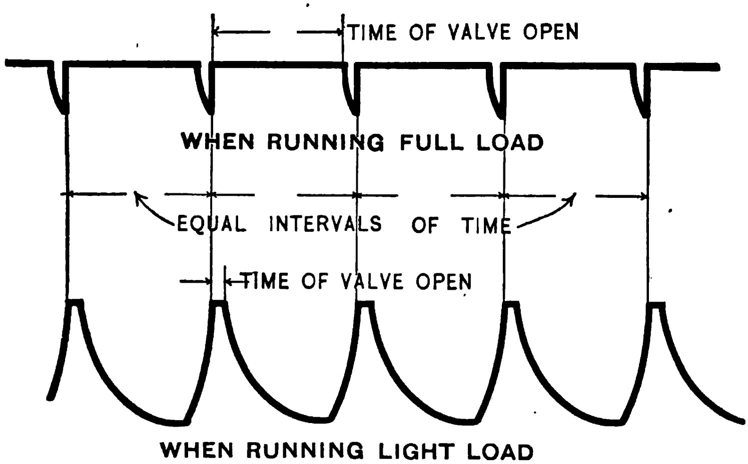

Fig. 7.—INDICATOR CARD, FROM ADMISSION CHAMBER.

reciprocating motion is transmitted to valve *A* and finally to the main admission valve. High pressure steam is thus admitted to the turbine in short puffs, with the frequency of about 150 strokes per minute. The function of the governor is to vary the plane of oscillation of the pilot valve *A*, thus varying the period of steam admission to the turbine in proportion to the load. "*A*" also operates as a safety stop; a large movement either way from mid-position results in shutting off steam to the admission valve. Thus the turbine will come to rest should a heavy short circuit occur or the governor mechanism break.

The action of the governor resembles somewhat that of a reciprocating engine. Fig. 7 represents a series of indicator

cards taken from the steam admission port at the high pressure end of the turbine, the drum of the indicator being rotated by hand. At full load the puffs merge into nearly continuous blasts. It should not be inferred from the diagram that the steam expansion at light load is more complete than that at full load, for the total expansion of steam is performed by the series of blades. The diagram shows, however, an important point: that high pressure steam is utilized at all loads instead of being throttled in proportion to the load of the turbine, thus favoring the attainment of best economy by utilizing the entire thermal range available; *i.e.* from boiler and condenser. This intermittent admission of steam does not in the least affect the uniformity of rotation and consequently of the voltage of the generator by reason of the great inertia of the rotating parts. It is, on the other hand, highly beneficial in preventing the sticking of governor parts.

In the larger sizes of turbine, an automatic over-speed governor is employed for the purpose of increased safety. It is mounted at the end of the turbine shaft, and may be set at a predetermined speed, at which the governor releases a small pilot valve which in turn operates through high pressure steam an auxiliary quick-closing throttle valve located in the main steam pipe.

With speeds as high as 3600 r.p.m., it becomes necessary to provide flexibility to absorb vibrations occurring while the turbine is passing its critical speed. The bearing used in turbines under 1000 k.w. capacity consists of a nest of loosely fitted metalic sleeves surrounding the shaft and resting in a self-aligning seat in the pedestal. Oil circulates between the sleeves and by capillary action fluid cushions are formed which restrain vibration and at the same time give sufficient flexibility to allow the shaft to revolve about its gravity instead of its geometric axis. The shaft is, therefore, built as rigidly as desirable, and the crystallization experienced in turbines employing flexible shafts is avoided. In turbines above 1000 k.w. capacity, a solid split self-aligning journal is used, as the speeds are so low as not to require the flexible journal. All bearing surfaces are sufficient to render forced lubrication unnecessary, as usually understood to mean, oil under high pressure; *i.e.*

pressure of several hundred pounds per square inch; and as the weight of the shaft is carried by oil films, practically no wear is experienced. This is evident from the fact that after

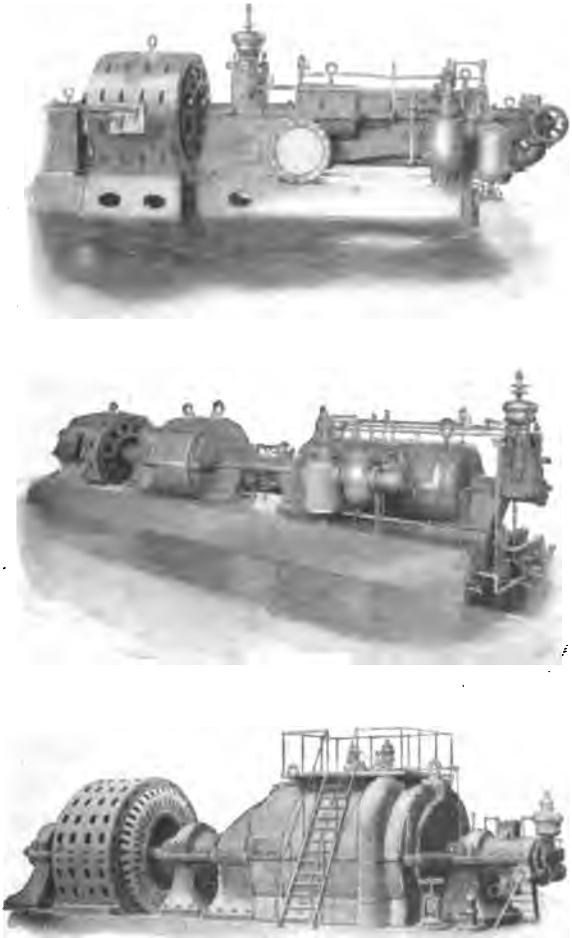

Fig. 8.— WESTINGHOUSE-PARSONS STEAM TURBINES.
400 KW., 1,500 KW., and 5,500 KW.

several years operation, a turbine bearing, after the dismantling of the machine, showed the original tool marks upon the inner shell.

In furnishing the oil supply for the turbine bearings, a small

plunger pump, driven by the turbine itself, is employed. Referring again to the sectional view, this pump is shown at *M*, and circulates oil through a closed system comprising in the order of their arrangement : pump, oil cooler, bearings, and reservoirs *O* and *N*. The pressure impressed upon the oil films at the bearings is equivalent to a static head of one to three feet, no oil under high pressure being used in the turbine. It is hardly necessary to emphasize the utter simplicity of this system of lubrication and the soundness of engineering judgment behind it which avoids the hazard incident to high pressure oiling systems in the hands of careless or incompetent operators.

Commercial Features.

Let us now consider for the moment some of the commercial aspects of the turbine :

Simplicity: A feature which is so clearly obvious in the case of the turbine hardly needs mention. Some misdirected criticism has, however, appeared concerning the use of a large number of vanes as constituting complexity of construction. The charge of complexity can only be made against a machine when its general operation and life in regular service is affected. As long as a machine runs indefinitely without trouble and to the entire satisfaction of its owner, the interior construction is a matter of secondary importance. To have produced a prime mover consisting of two elementary parts, one stationary and the other employing the simplest form of motion,—*viz.* that of rotation, — is in itself an accomplishment that reflect the utmost credit upon the designers of the steam turbine. To have, in addition, exceeded the highly developed piston engine in economy, compactness and general ease of manipulation, may be considered the greatest accomplishment of the past century in the field of mechanics.

An engineer, thoroughly conversant with the construction and operation of the steam turbine, has recently characterized it as "fool-proof." This terse expression, inspired by personal experience with a turbine equipment, later described, speaks volumes.

Permanence: The question has often been raised whether the steam turbine is permanent in its adjustment and economy,

and whether its rate of depreciation is high or low. As there is apparently nothing to wear out except the bearings and blades, we should expect little deterioration. That this is the case is shown by a test by Professor Ewing upon a 500 k.w. Parsons machine that had been in daily lighting service for twelve months. The official shop test showed an economy of 17.95 pounds of steam per e.h.p. hour under the same conditions as later obtained at the plant. After the year's service an economy of 18.63 pounds was observed. In the later test, however, the turbine was driving its own air pump, whereas in the shop tests the pump was independently driven. The small difference — 3 per cent. — indicates an increase rather than a decrease in economy with time.

Similar results have been obtained upon a 300 k.w. Parsons turbine at Harrogate: * The full load economy before and after nineteen months' continuous service was 16.9 and 15.75 pounds per e.h.p. hour respectively. A somewhat higher speed in the second test improved the economy slightly.

In the case of the New Castle and District Electric Lighting Company, England, the total cost of repairs upon the turbine plant, the larger part of which had been in continuous operation for eleven years, averaged .225 cent per k.w. year, or .039 mills per k.w. hour at the switchboard.

Compactness is largely due to the high speed of the turbine as compared with the reciprocating engine, and the more effective use of materials. This feature applies with peculiar force to the engineer confronted with the problem of providing adequate building capacity at reasonable cost. Power house extensions are furthermore not always possible, either from lack of ground, imminence of winter loads, or the broad proposition of ultimate cost. The turbine, therefore, in addition to its ideal fitness in a newly designed power station, is peculiarly adapted to power extensions in locations where the required increase in building and engine capacity is impossible. In round numbers, the floor space occupied by a turbine of moderate size (1,000 k.w.) is 2-3 of that required for a vertical and 1-5 of that necessary for a horizontal piston engine of the cross-compound Corliss

* Wilkinson, London Electrician, October 23, 1903

type, operating condensing. The height of the turbine is similarly about 2-3 that of the horizontal and 3-10 that of the vertical engine. Fig. 9 shows the actual relation of floor space to rated capacity for the three types of prime movers, also the general limitations of piston and engine capacities. Over-all dimensions have in all cases been used. It will be observed that the minimum space for the horizontal Corliss is 0.73 square

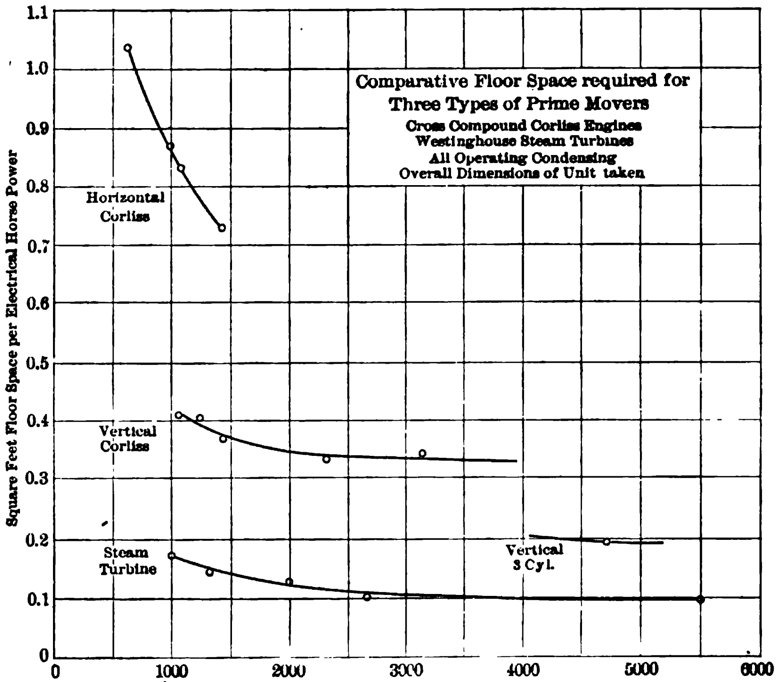

Fig. 9.

feet per e.h.p.; for the vertical Corliss 0.33 square feet, and for the turbine 0.1 square foot.

In weight per unit of output, the turbine likewise exceeds the high grade engine unit of equal capacity by 70 per cent. to 80 per cent.

Foundations of any character strong enough to withstand the dead weight of the turbine unit are sufficient, for the reason that reciprocating stresses and vibrations which must be provided for and absorbed in the reciprocating engine are absent

in the turbine. Foundation bolts may even be dispensed with, and in many cases simply a structural steel floor has been provided; in others two narrow concrete walls as shown in Fig. 26. One interesting instance is that of a turbine power station which is floated bodily upon a salt meadow, the entire power station resting upon a concrete plate.

Subdivided power: The old adage that "it does not pay to put all one's eggs into one basket," applies particularly to power station design. Even in view of the higher economy of large engine units, it often occurs that a number of small units are specified in order to secure a reserve margin of power. This becomes particularly necessary on widely fluctuating station loads, on account of the relatively poorer economy of the steam engine at fractional loads. With a turbine, however, which maintains its economy over a much wider range of load, the advantages of subdivided power may be realized without the loss in economy encountered in a piston engine. There is further, comparatively little difference between the economy of small and large turbines, which admits of a choice of the most convenient size of units for any particular plant and service.

Parallel Operation: The periodical variation in rotative speed during each revolution of a reciprocating engine has proven the most complex and troublesome problem in the operation of alternating current generators in parallel. This difficulty is due both to the angularity of the connecting rod and to the extreme variation in torque upon the shaft at each piston stroke. These variations induce heavy cross currents between generators, causing violent surging of load from one machine to the other, unless damping devices are used on the generators and massive fly-wheels on the engine. This difficulty is entirely avoided in the turbine. The angular velocity and, consequently, the torque upon the shaft is absolutely uniform, which, combined with high rotative inertia and absence of reciprocating motion, provides the ideal conditions for operation in parallel. Synchronizing of the generators also becomes a simple matter. With proper manipulation of the spring adjustment on the governor, it becomes possible to lengthen out the synchronizing period to minutes instead of seconds, as in the

case of engine type units. The safety of an engine equipment depends largely upon the skill and alertness of the attendant in approximating the synchronizing period. With the turbine there is little excuse for the attendant getting "rattled" and throwing the generators in out of step.

Oil: The cost of feed water in power stations located so that water must be purchased from a city system forms an important item of station expense. As no oil is used in the interior of the turbine, the condensed steam is therefore pure distilled water, provided surface condensers are used, and may be returned directly to the boilers. Thus, the cost of feed water, together with the cost of purifying it in case its mineral ingredients cause incrustation, is avoided; also the cost of cylinder oil; while the amount of bearing oil required is so small as hardly to become a factor in the total cost of operation. During one year's continuous service the four 400 k.w. turbine units at the Westinghouse Air Brake Works required thirteen barrels of oil at 41 cents per gallon. The cost of oil for each turbine was thus slightly over 5 cents per day of 24 hours. Oil of good quality may be used continuously for several months, when it should be filtered, and may then be used again in the turbine; this process may be continued until the gradual vitiation of the lubricating properties of the oil makes it desirable to replace occasionally a small percentage by fresh oil. That removed is suitable for ordinary machinery, and is frequently used in plant auxiliaries. It does not therefore represent a waste in the ordinary sense of the word, and compared with reciprocating engine practice represents but about 10 per cent. of that usually necessary. In several plants which have been in operation for some time it is found that the turbines use about 1.4 gallon per k.w. per year.

Temperature Range: The advantages of high initial and low terminal temperatures in a heat engine have long been recognized as practically the only avenue of improvement remaining in reciprocating steam engine practice. A distinct barrier has, however, been interposed by the difficulties in designing valves, pistons and cylinders, and the necessity of dispensing with cylinder lubricant. A few engines of recent design, employing poppet valve construction, do employ superheated steam rang-

ing as high as 250 deg. F. above saturation, but as a general rule the resulting cost and complexity of construction prevents the general application of superheat in piston engine work. On the other hand, the inherent simplicity of construction of the turbine facilitates the use of the highest superheat and lowest exhaust pressure.

A high vacuum may of course be used with reciprocating engines, but the advantages to be secured are not so marked as in the case of turbines in which the steam is able to expand down to condenser pressure. The question of how high a vacuum shall be used is largely one of cost and conditions of operation. For any given set of conditions, the most economical vacuum may be determined by comparing the increase in cost of equipment to the saving of coal consumption capitalized upon a basis of length of life of the machine in question. The cost of a complete condensing equipment, consisting of surface condenser, rotative dry vacuum pump, and auxiliaries, increases in round numbers from $4.00 per kilowatt at 26 inches vacuum * by 20 per cent. to 30 per cent. for each additional inch, the increment increasing rapidly with vacua above 28 inches Hg.

The accompanying chart (Fig. 10) was prepared for facilitating estimation of power station economies using the cost of fuel as a basis. Starting with the fuel, we trace the cost of power through a year's operation and, by assigning increased economy at one point or the other, express this economy in terms of dollars to be applied to the initial investment. Following the trial setting shown, we make the following arbitrary assumptions for two typical stations:

Gross evaporation	7½ pounds per pound coal.
Cost of coal	$2.00 per ton.
Gross steam economy of a turbine station	20 pounds per k.w.h.
Gross steam economy of an engine station	30 pounds per k.w.h.
Daily run	24 hours.
Life of equipment	15 years.

The fuel cost of power is, for the engine station, 0.28 cent per k.w. hour, and for the turbine station 0.41 cent per k.w. hour, a saving of 0.13 cent. Applying this saving to the lower half of the chart, it amounts in fifteen years to $170 per kilowatt.

* Referred to 30 inches barometer.

This represents the capitalized excess economy of the turbine station over the engine station through their normal life, and, consequently, a credit item on the side of the turbine. Under the assumptions the saving far exceeds the first cost of the

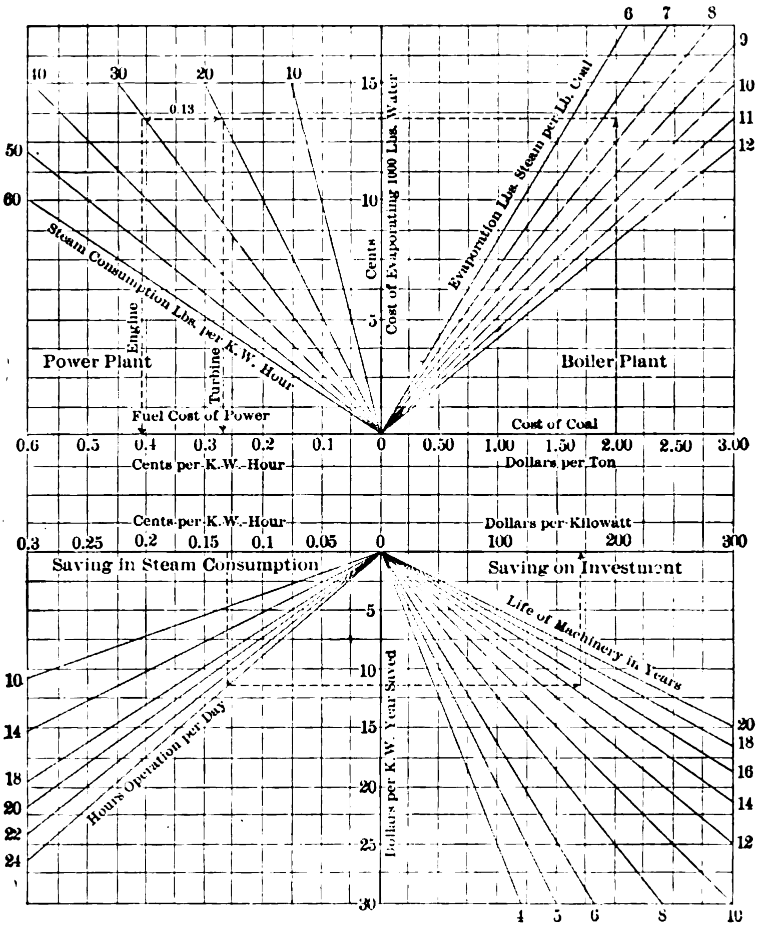

Chart showing Capitalization of Saving in Cost of Fuel Due to More Efficient Prime Mover

Fig. 10.

entire turbine equipment. But, this assumed difference of 10 pounds may be thought excessive. Suppose, then, that the two stations operated with the same economy; *viz.* 25 pounds steam per k.w. hour with 26 inches vacuum,—and that the tur-

bine vacuum were then increased to 28 inches Hg.; will a saving result? Tests indicate that the turbine will increase from 3 per cent. to 4 per cent. in economy with each inch of vacuum above 26 inches Hg. The turbine station economy will then average 23 pounds per k.w. hour, and the difference—2 pounds—amounts to about $35 per k.w. through its life. The new condenser has, however, necessitated an extra investment of $2.50 per k.w., so that the net saving is $32.50 per k.w.—thirteen times the cost of the increased vacuum. The saving, to be sure, varies somewhat with conditions of operation, but it is evident that with a machine upon which the rate of depreciation is so low as the turbine, any reasonable means of increasing station economy will be fully warranted. It is also patent that higher average plant economy may be derived from a turbine than from a reciprocating engine station. Let us glance, therefore, at the results of some tests.

Economy: The builders of the Westinghouse-Parsons turbines early provided a completely equipped testing department in which all sizes of machines could be tested before shipment, in order to establish beyond question their performance under service conditions. This department occupies about 11,000 square feet of floor area and contains a boiler plant, three separate condensing equipments suitable for maintaining vacua up to 29-30 absolute, and an independently fired superheater for running superheated steam tests, together with a complete water weighing equipment and standardizing laboratory for meters and instruments. Up to the present time over 1,000 test runs of an hour or more duration have been made upon turbines of various capacities, and from the records a few have been selected at random.

The general relation of economy to load is shown in the test (Fig. 11) of a 1,500 k.w. turbine now operating in the power plant of the DeBeers mines, Kimberley, South Africa. It will be observed that the total water rate line, sometimes called the Willans line, in engine practice is practically a straight line. This means that the turbine uses steam with the same thermodynamic efficiency at all loads; in other words, that the losses, both thermal and mechanical, are reasonably constant. It does not mean of course that the water rate of the turbine is

constant, for, with constant losses, the proportion of lost work to useful work in a prime mover gradually increases as the load decreases with a corresponding decreasing total efficiency. In the test shown, a minimum water rate of 12.66 pounds per e.h.p. was recorded which is equivalent to 10.75 pounds per i.h.p. at the usual total efficiency of 85 per cent.

Another striking characteristic of the turbine is the remarkable flatness of its water rate curve. At half load the consumption is not usually greater than 10 per cent. in excess of

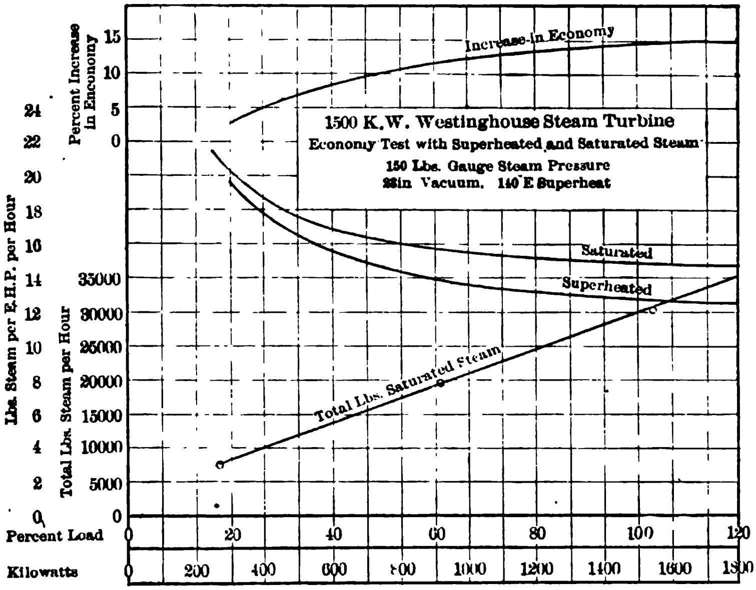

Fig. 11.

the consumption at full load, while on overloads, the steam consumption decreases progressively. Thus within a range of 75 per cent. of the normal rating of the machine — *viz.* from 1-2 load to 25 per cent. overload — the economy of the turbine varies less than 15 per cent. of its full load economy. To this fact may be attributed the high all-day economy of a turbine power station.

In the parallel-flow type of turbine, large overload capacity is usually secured by the use of a secondary valve, similar in design and operation to the primary admission valve, and which

admits high pressure steam into one of the intermediate expansion stages, thus raising the internal pressure and the power of the turbine.

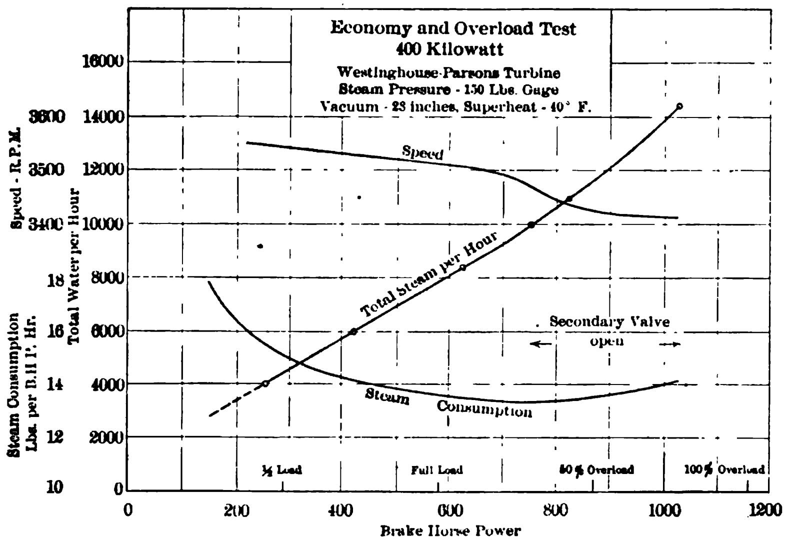

Fig. 12.

Fig. 12 shows the effect of the secondary or overload valve. The results were obtained upon a 400 k.w. turbine now in operation in the power plant of the Yale & Towne Manufacturing Company, Stamford, Conn. In the test recorded, the valve was operated automatically from the governor, so that the steam admitted to the turbine through it was proportioned to the overload in precisely the same manner as that entering through the regular admission valve. As soon as the load had increased sufficiently to occasion a noticeable drop in speed, the secondary valve opened and prevented further lowering of speed. The turbine in this case carried an overload of 75 per cent. The curve resembles somewhat that of a piston engine with, however, this exception; that, whereas the steam consumption of the engine increases on all loads above or below 3-4 load, that of the turbine remains nearly constant from 1-2 load to 25 per cent. overload.

Some recent tests upon the 1,250 k.w. units for the Rapid

Transit Subway power house, New York, are recorded in Fig. 13. They were supervised and verified by Julian Kennedy of Pittsburg. All tests were made with 150 pounds boiler pressure, and although the contract conditions called for 175 pounds pressure, the guaranteed economies were more than met. Curves *C* represent the economy with dry saturated steam at 27 inches vacuum, minimum water rate 14.4 pounds per e.h.p.; curves *E* saturated steam at 28 inches vacuum, 14 pounds per e.h.p.; curves *D* 75 degrees superheat and 27 inches vacuum, 13.75 pounds per e.h.p.; curves *F*, 76 degrees superheat and 28

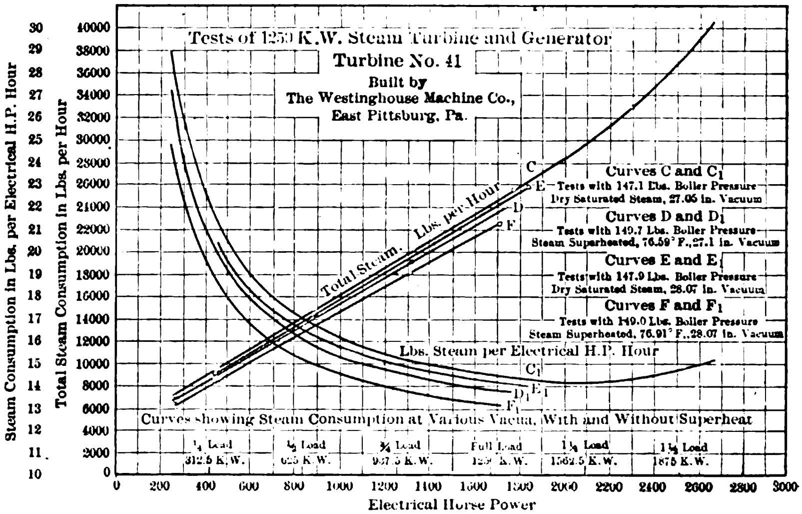

Fig. 13.

inches vacuum, 13.25 pounds per e.h.p. Curve *C* also shows the effect of the secondary valve on overloads. In this case it was manipulated by hand instead of by the governor as is usually the case.

Reference has already been made to the economy to be derived from superheat and high vacuum. This relation is shown in a striking way by results upon a 1,500 k.w. turbine, Fig. 14. Starting with low vacuum and dry saturated steam, the steam consumption was reduced 3.74 pounds per e.h.p. by increasing the vacuum 3 inches and superheat 140 degrees.

Although these conditions are readily obtainable, it some-

times occurs that the turbine is required to operate under low pressure and with no vacuum or superheat, and it is of interest to observe that even under these conditions admirable performance may be realized. These results are due to a certain extent to the low steam velocities employed in the turbine A test upon a 400 k.w. turbine operating with 125 pounds boiler pressure, dry saturated steam and 26 inch vacuum shows an economy of 15.41 pounds per brake horsepower at full load, and at half load 18 pounds per brake horsepower.

Tests upon a 1,000 k.w. turbine for the Cleveland, Elyria &

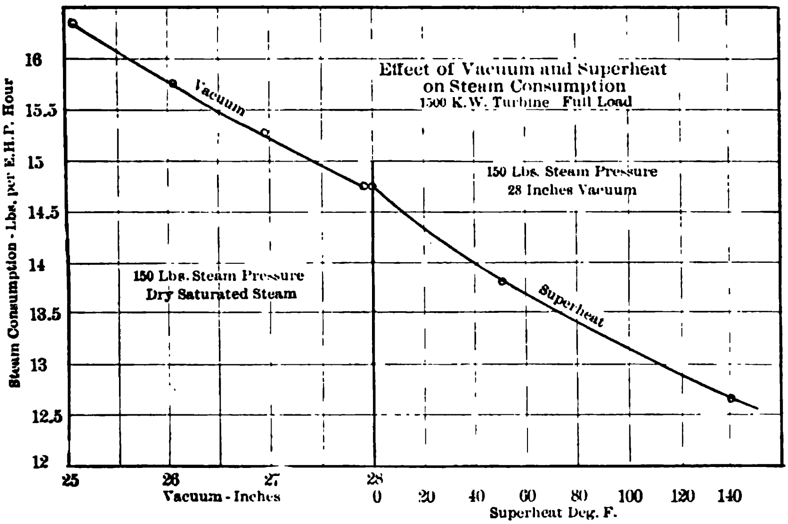

Fig. 14.

Western Railroad, under 27 1-2 inches vacuum, 146 pounds pressure and 28 degrees superheat, showed a minimum economy of 13 67 pounds per e.h.p. A 400 k.w. turbine under 150 pounds pressure, 28 inches vacuum and 100 degrees superheat, showed a minimum economy of 13.5 pounds per e.h.p. at full load. The same turbine with saturated steam, 140 pounds pressure and 26 inches vacuum, showed 15.25 pounds per brake horsepower at full load.

It has been customary to express engine performance in terms of *indicated* horsepower, particularly in large sizes where it is usually impracticable to determine brake horsepower,

thus the results are shrouded in a certain amount of uncertainty due to undetermined engine and generator losses. In the case of the turbine, the performance must necessarily be expressed in tangible units of useful work — *viz* : brake horsepower or electrical horsepower. It therefore becomes necessary, in order to draw an exact comparison between engine and turbine to estimate turbine losses upon a basis of known engine losses.

An interesting series of tests was recently performed on a 400 k.w. turbine by Messrs. Dean & Main, engineers of this city. The results are recorded in Fig. 15. With 26.9 inches

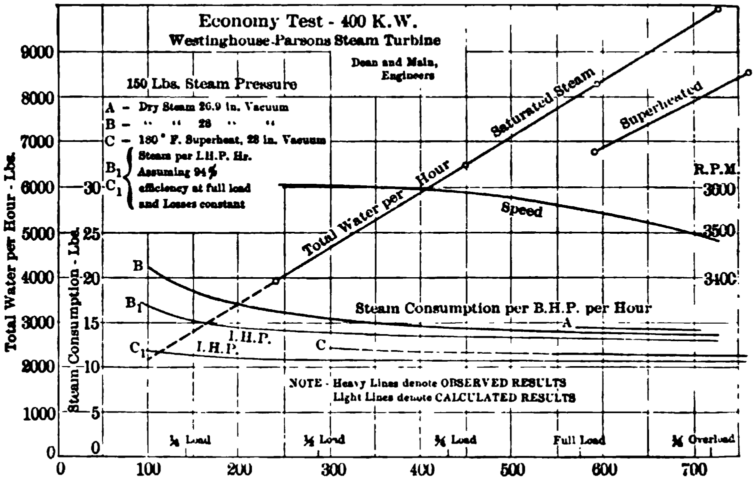

Fig. 15.

vacuum and dry saturated steam at 156 pounds pressure, a water rate of 14 pounds per brake horsepower hour was observed. Increasing the vacuum to 28 inches decreased the water rate to 13.63 pounds per b.h.p., which was further lowered to 11.17 pounds per b.h.p. with 180 degrees Fahrenheit superheat. Thus the gain due to 1.1 inches at full load was 2.4 per cent. and to 180 degrees superheat, 10.5 per cent. The method above referred to of obtaining the indicated water rate has been applied to these results, as shown in curves B_1 and C_1. A b.h.p.÷i.h.p. efficiency of 94 per cent. was assumed, giving a water rate of 13.07 pounds per internal horsepower with saturated steam;

and 10.76 pounds per i.h.p. with 180 degrees superheat. The corresponding thermal efficiencies obtained by Messrs. Dean & Main upon the basis of $\frac{\text{Heat Equiv. of Work Done}}{\text{Heat Input in B. T. U}}$ were 17.22 per cent. for saturated steam and 19.43 per cent. with superheated steam. As the maximum efficiency available under the conditions from the Carnot cycle is 32.5 per cent., it is evident that the turbine has attained nearly two-thirds of its possible thermal efficiency as a heat engine under the conditions of test. *

In engine economy, results vary widely with arrangement of valves, and the condition of pressure and superheat. Prof. Jacobus † gives results upon a four-valve engine which fairly represent the best obtained with well-designed piston engines operating under favorable conditions. Usually the economy is much lower. The minimum water rate with jackets and reheater in service was 12.1 pounds per i.h.p. Professor Barrus in his "Engine Tests" gives results upon eight four-valve compound condensing engines, operating under 100 to 150 pounds steam pressure and 25 to 26 inches vacuum. At an average load of 570 i.h.p. the average minimum water rate was 14.35 pounds per i.h.p. At 85 per cent. combined engine generator efficiency, this is equivalent to 17 pounds per electrical horsepower hour, or 22.6 per kilowatt hour. It thus appears that if the turbine can show an economy of less than 15 pounds per useful horsepower at full load, it has already exceeded average engine economy. As a matter of fact it has already approached 10 pounds.

The entire subject of comparative economy between engine and turbine may be dismissed with the pertinent reflection of a prominent engineer who says: "Even if the steam consumption of the turbine were no lower than that of the piston engine, there will still be an important saving in favor of the turbine in cost of building, up-keep, oil, and attendance."

Turbine Installations.

We will conclude by considering a few turbine installations now in operation.

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* $\frac{T1 - T2}{T1} = \frac{828 - 575}{828} = \frac{253}{828} = 32.5$

† Trans. A. S. M. E., December, 1902.

The power station of the Westinghouse Air Brake Company, (Fig. 16) at Wilmerding has been in continuous service since 1899, at which time the entire conversion of the works from distributed steam engine to motor drive was effected, all power coming from the turbine plant. An immediate saving of about 36 per cent. in fuel alone resulted from the conversion, part of which was of course due to the more efficient electric drive.

The installation at the plant of the Hartford Electric Light Company (Fig. 17) operates under very different conditions. The turbine is of 1,500 kilowatt capacity and when not in regular service is kept constantly under steam to serve as a relay to hydraulic plants located about eleven miles from Hartford, which normally serve that city by high-tension transmission.

During a year of normal rainfall, the steam plant is operated for about three months, and for the same period the heavy winter loads. The turbine, together with vacuum and circulating pump, may be started and load applied within seven minutes and, during interruptions of service from the hydraulic plants due to ice or line troubles, it has carried the entire station load of 2,200 k.w. for four hours without trouble. Allowing for liberal passageways, the turbine occupies .35 square feet per e.h p — less than 1-12 the space occupied by auxiliary horizontal compound Corliss engines belted to generators. Efficiency tests conducted by Prof. W. L. Robb under regular operating conditions showed a minimum steam consumption of 14.23 pounds per e.h.p. and a corresponding coal consumption * of 1.23 pounds per e.h.p. hour under 155 pounds steam pressure, 27 inches vacuum and 42 degrees Fahrenheit superheat. Incidental tests conducted by the local force on the engine plant showed a steam consumption of 3.1 pounds per e.h.p. hour on an all day run at full load and 3.6 pounds on lesser load. Another worthy feature of the installation is that steam turbine and hydraulic turbine units operate in parallel over the transmission line with the greatest ease, and synchronizing of generators is accomplished in the ordinary manner. The turbine plant will shortly be augmented by two 750 kilowatt units, displacing the present engine equipment.

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* Georges Creek run of mine.

Fig. 16.— WESTINGHOUSE AIR BRAKE CO., WILMERDING, PA.
4 400-kw. turbine units, power and light, factory.

Fig. 17.— HARTFORD ELECTRIC LIGHT & POWER CO., HARTFORD, CONN.
1500-kw. turbine unit, light and power, general distribution.

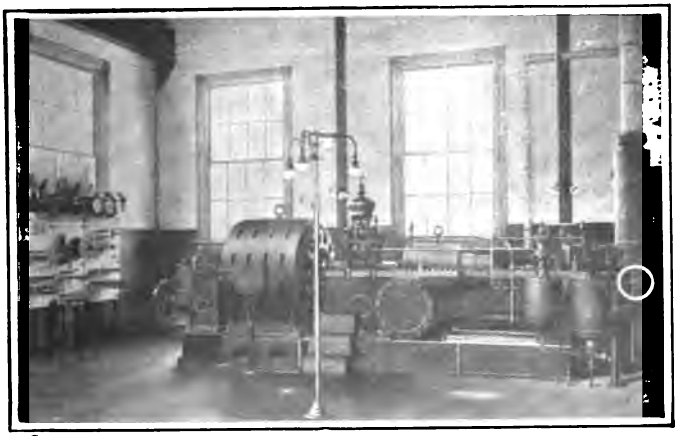


Fig. 18.— JOHNSON HARVESTER CO., BATAVIA, N. Y.
400-kw. unit, power and light, factory.

In 1901 the Yale & Towne Manufacturing Company, Stamford, Conn., adopted the electric motor drive throughout their extensive works, with power furnished from a turbine plant. Owing to the power building being enclosed by other buildings, extensive additions were impossible. Where no room existed for another engine a turbine with its condenser was installed and the plant doubled in capacity (Fig. 19). A second turbine was later installed in a small addition to the building. Half of the power house is occupied by an engine and air compressor, aggregating without condenser 350 i.h.p.; and half by the turbines aggregating 800 k.w. or about 1,250 i.h.p. A central condenser is employed, serving two turbines. The floor space occupied by the Corliss engine is 6 3-4 times that required for the entire turbine outfit, with condenser. Exhaustive tests * upon the power system, conducted by Superintending Engineer F. A. Waldron, showed a steam consumption at the motor shaft in the factory of 20.62 pounds per e.h.p. and a coal consumption of 2.37 pounds per horsepower, these figures representing an average of 13 motor drives of different character. 150 pounds steam, 27 inches vacuum and 440 volt, 2-phase distribution were used.

During cold weather the turbine plant operates non-condensing through a regular schedule of hours, supplying exhaust steam to the works for heating. The back pressure on the turbines is reduced to about 3-4 pound by a suction system, and full load is maintained by means of the secondary valve previously referred to. An interesting feature of the boiler plant is that ordinarily a superheat of 15 to 20 degrees Fahrenheit is obtained at the turbine, due to the boiler tubes extending above the water level, thus forming a superheating surface.

Another important example of the turbine in industrial works may be found at the B. F. Goodrich Company, Akron, Ohio, which was likewise converted from steam to electrical drive with power from a central station. Fig. 20 shows the turbine units, the engine room containing 1,150 k.w. in horizontal compound Corliss units and the same capacity in turbine units. Where no room formerly existed for an additional engine unit, it has been possible with turbines to double the capacity of the plant.

* Trans. A.S.M.E., June, '03.

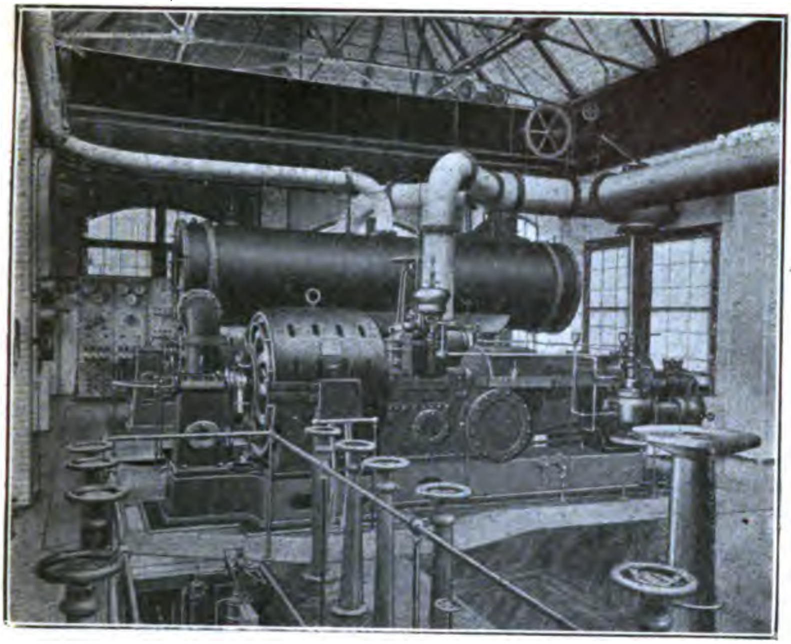


Fig. 19.—YALE & TOWNE MANUFACTURING CO., STAMFORD, CONN. 2 400-kw. units, power and light, factory.

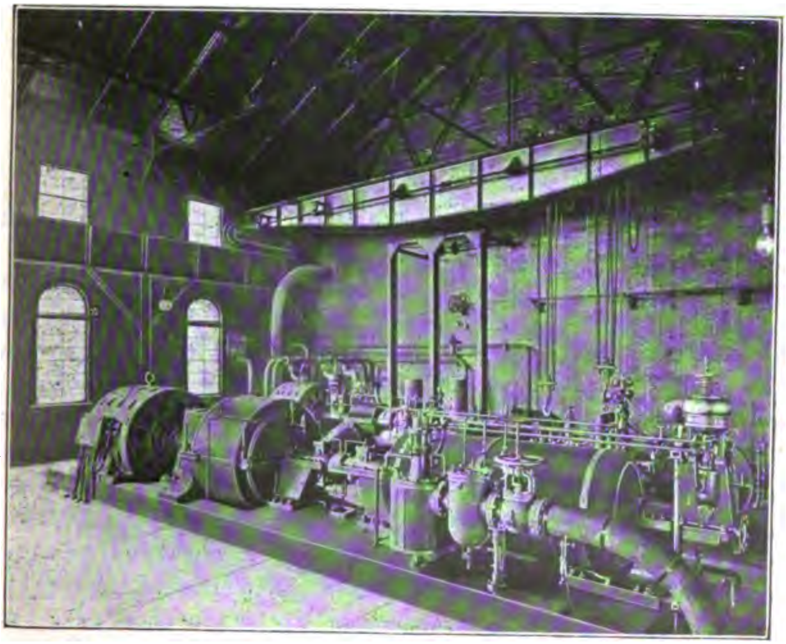


Fig. 20.—B. F. GOODRICH MANUFACTURING CO., AKRON, OHIO. 1 750-kw. and 1 400-kw. turbine units, power and light, factory.

The turbines occupy 0.64 square feet per horsepower —about one-third of that necessary for the engine type units.

The compactness of this arrangement is partly due to the novel location of the condenser which serves both turbines and stands in a concrete pit in the basement, crosswise to the foundations instead of lengthwise as usual. Both turbines rest on composite foundations consisting partly of brick pier walls and partly of steel "I" beams spanning the condenser pit. The plant load is mainly furnished by about 4,000 h.p. in connected motors, both A.C. and D.C., a number of which are 300 h.p. induction motors. It thus occurs that widely fluctuating loads are encountered. It is a striking feature of the equipment that turbine and engine units operate in parallel with perfect ease,

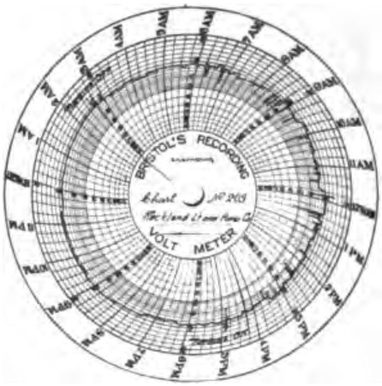


Fig. 22.—VOLTMETER RECORD, ROCKLAND LIGHT & POWER CO.

due to the steadying effect which the turbine exerts through its high rotative inertia.

Fig. 18 shows the turbine plant recently put into service at Batavia, N.Y., for operating the works of the Johnston Harvester Company. Twenty-six inches vacuum is ordinarily carried, but during cold weather the vacuum is lowered and the increased temperature of the exhaust steam made use of by a tubular heater supplying the hot water heating system in the works.

The Rockland Light & Power Company, Nyack, N. Y., are operating a turbine (Fig. 21) in their power station at Orangeburg. This machine also labors under low vacuum, 24 to 26 inches, furnished by a jet condenser. The effect of the turbine on voltage regulation is shown in Fig. 22, a chart taken at

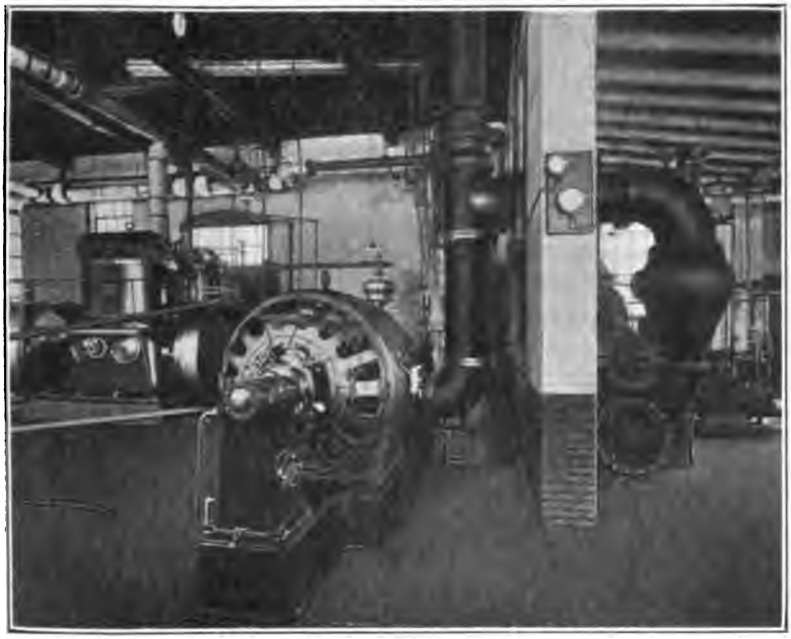


Fig. 21.—ROCKLAND LIGHT & POWER CO., ORANGEBURG, N. Y.
1 400-kw. turbine unit, light and power, general distribution.

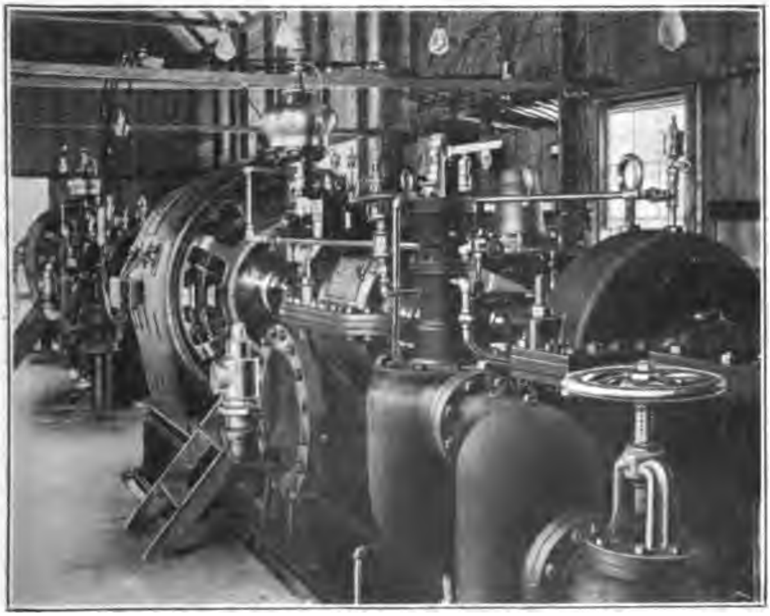
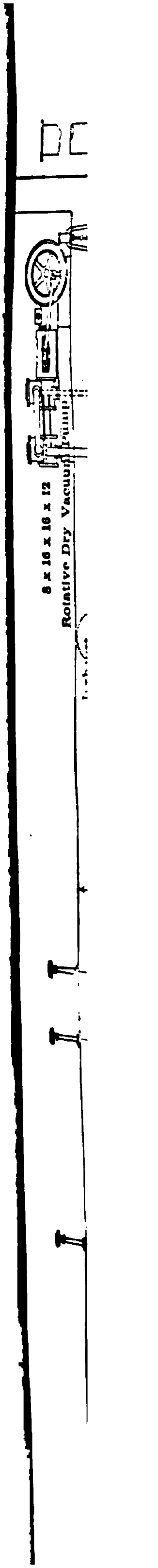


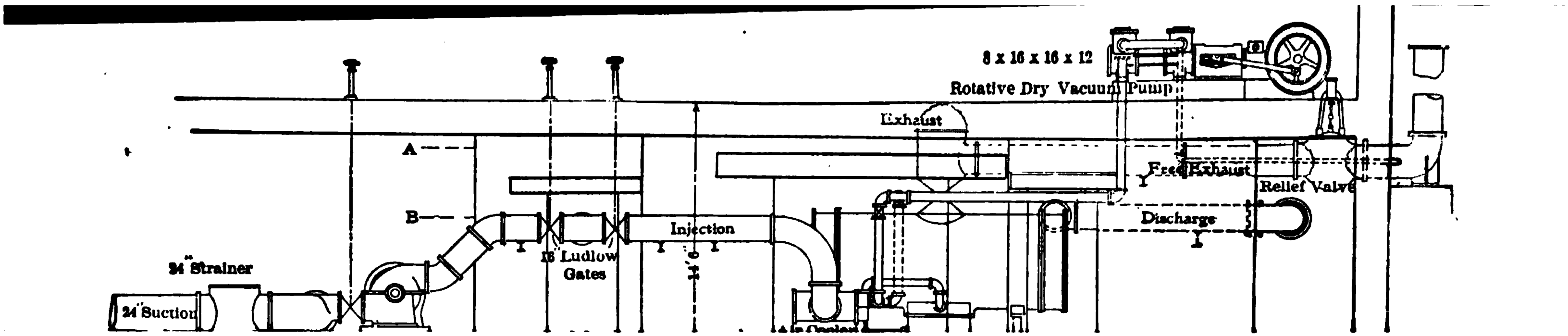
Fig. —NASSAU LIGHT & POWER CO., ROSLYN, L. I.
2 400-kw. turbine units, railway system, light and power for general distribution.

Nyack several miles distant. The turbine carries the night load from 5 P. M. to 3 A. M., and engines the day load, in which the excessive fluctuations are mainly due to motors.

One of the first railway plants using turbines was the Nassau Light & Power Company, Roslyn, L. I., which applies power for railway and lighting and power throughout the surrounding district. As a result of rapidly increasing station loads, the turbine plant was installed, under temporary and highly adverse conditions (as may be judged from Fig. 23, the interior of the the present turbine building). During erection one of the turbines slipped from the wet staging blocks to the ground, six feet below, landing bottom side up. After a critical examination of both stator and rotor, no damage was observed nor alteration of adjustments. Shortly after, through the burning out of a reserve generator, this turbine was hastily connected to steam and switchboard and put immediately into service, exhausting into atmosphere and sustaining a considerable overload by the help of the secondary valve. The plant has been running ever since, except when exhaust connections were made.

An exclusively railway plant is that of the Cleveland & Southwestern Railway Company (Fig. 24). Important extensions into territory distant from the power house at Elyria, Ohio, necessitated A.C. transmission at high voltage, for the supply of which turbines were introduced. Fig. 25 shows the present engine-room plan. 1,000 k.w., D.C. engine type machinery occupies one-half, and 2,000 k.w., A.C. turbo-machinery the other half, with still room for a third 1,000 k.w. turbine unit. The turbines as installed occupy .67 square feet per e.h.p., allowing for passageways. Fig. 26 shows the arrangement of condensing machinery. Each condenser is set directly beneath its turbine within the foundations, which consist of two parallel concrete walls 20 inches in thickness at the top, each pierced by openings for the accommodation of piping. Maximum economy of space is evidently realized with this arrangement, which cannot be employed with any other type of steam engine. Each centrifugal circulating pump is driven directly by a D.C. motor from the station bus bars. Superheated steam is used in the turbines, furnished from a





8 x 16 x 16 x 12
Rotative Dry Vacuum Pump
Exhaust
Free Exhaust
Relief Valve
Discharge
Injection
A
B
16" Ludlow
Gates
24" Strainer
24" Suction
Air Cooler

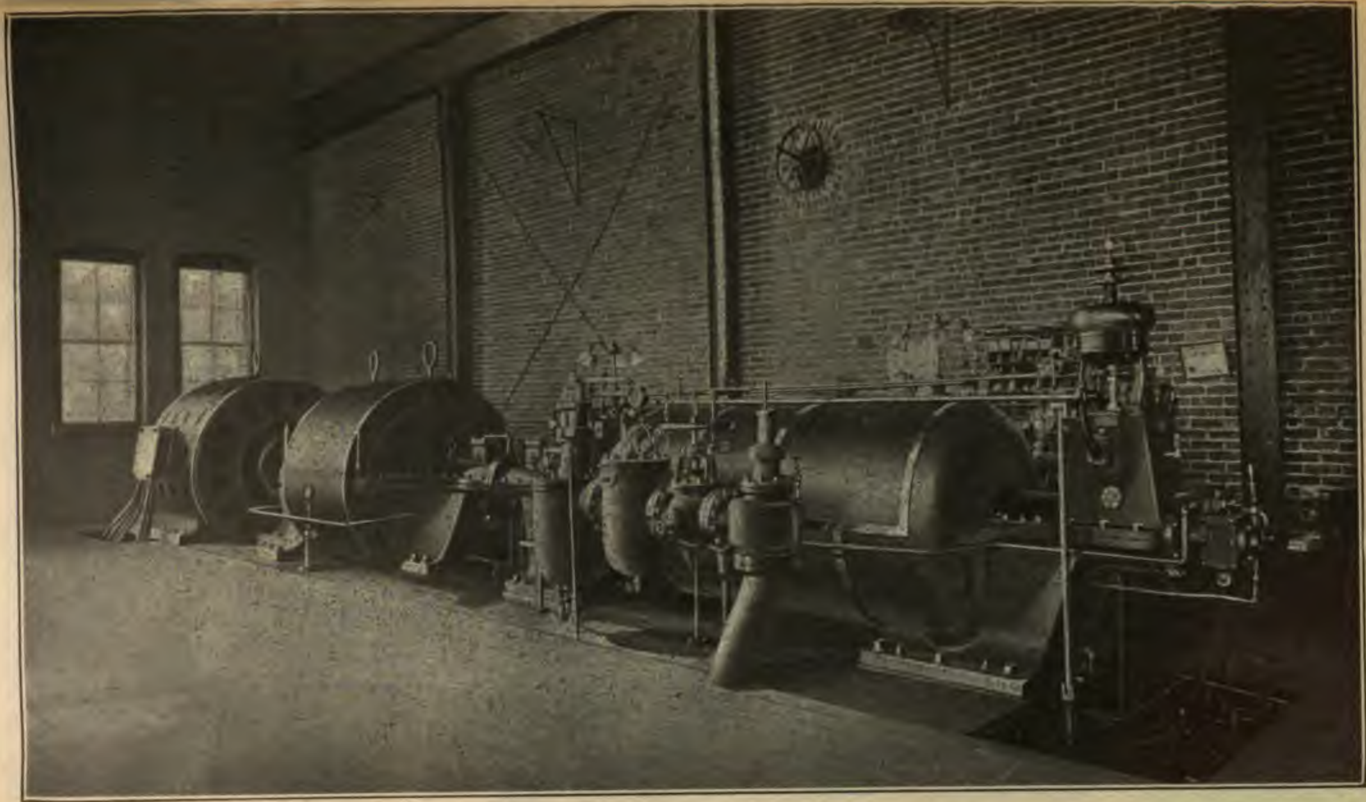


Fig. 24.—CLEVELAND & SOUTHWESTERN RAILWAY CO., ELYRIA, OHIO.
2 1000-kw. turbine units, railway system, employing high tension transmission.

superheater arranged to be placed in series with the furnace gases, or bypassed as desired, by the damper shown (Fig. 27).

A similar A.C. turbo-transmission system is employed by the Consolidated Railways & Lighting Company, Wilmington, N. C., for operating a suburban railway extending to the coast, and for lighting the summer resorts there located.

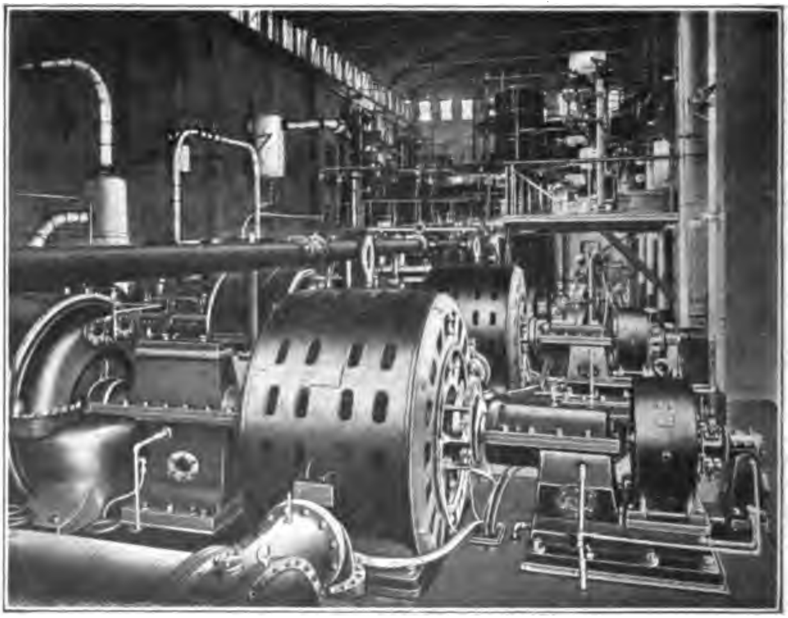
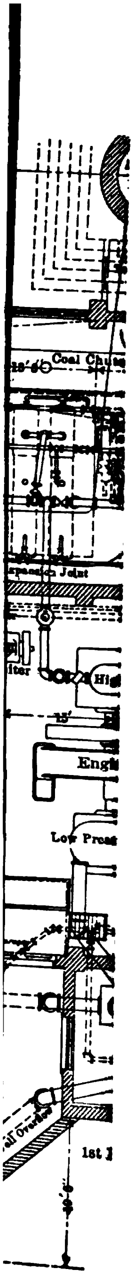


Fig. 28.—WEST PENN RAILWAYS & LIGHTING CO., CONNELLSVILLE, PA. 3 1000-kw. turbine units, light and power for general distribution.

A power plant of striking design is that of the West Penn Railway & Lighting Company at Connellsville, Pa., which serves the entire district within a radius of 25 miles with A.C. power for traction power, incandescent and arc lighting by high tension transmission. Railway and lighting equipments are separate, the one 25 cycle engine-driven, and the other 60 cycle turbine driven. Fig. 29 shows the general plan. Half of the engine room is occupied by three 1,000 k.w. vertical Corliss units and auxiliaries, and the other half by three 1,000 k.w. turbine units, with sufficient space remaining for two additional turbo units. Each turbine requires .234 square feet per e.h.p. Figs. 28 and 29 (A B) give a good comparison of the difference



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in head room necessary for the two prime movers. Foundations for each turbine unit consist of two battered concrete walls 18 inches thick at the top. The surface condensers are set between foundations, and are served by centrifugal circulating pumps driven by DeLaval steam turbines. Twenty-eight inches vacuum is secured by a pair of rotative dry vacuum pumps. Within 2½ months after starting the turbine plant the coal consumption per kilowatt hour was reduced 44 per cent. About 15 per cent. of this could be traced to the completion of the pipe covering, and the remainder to a slightly increased engine load factor and to the superior turbine economy.

These few installations will serve to show what is being accomplished through the steam turbine. Many others might be cited, such as the S. D. Warren Co., Cumberland Mills; Saco & Pettee, Biddeford; Atlantic Mills, Providence; Jos. Benn & Sons, Providence; Sherwin-Williams Co., Cleveland; Citizens Light, Heat & Power, Johnstown; Portsmouth (Ohio) Street Railway & Lighting Co.; City of Columbus, etc.

Finally, it may be of interest to observe the arrangement of machinery in the 75,000 horsepower turbine station now building by the Philadelphia Rapid Transit Company. Fig. 30 shows the general design, which, however, is understood, from Mr. Twining, Chief Engineer, to be a preliminary study plan as regards the precise arrangement of the units. The turbine equipment occupies .325 square feet of the room per e.h.p., but somewhat closer arrangement would be possible if called for.

I fear that I have grievously trespassed upon your patience in presenting this subject at such length. But I believe it is one of absorbing interest to the man associated in power development enterprises, and if the sum total of information upon the subject has been ever so slightly increased this evening, the author will consider himself well repaid.

Gentlemen, I thank you.

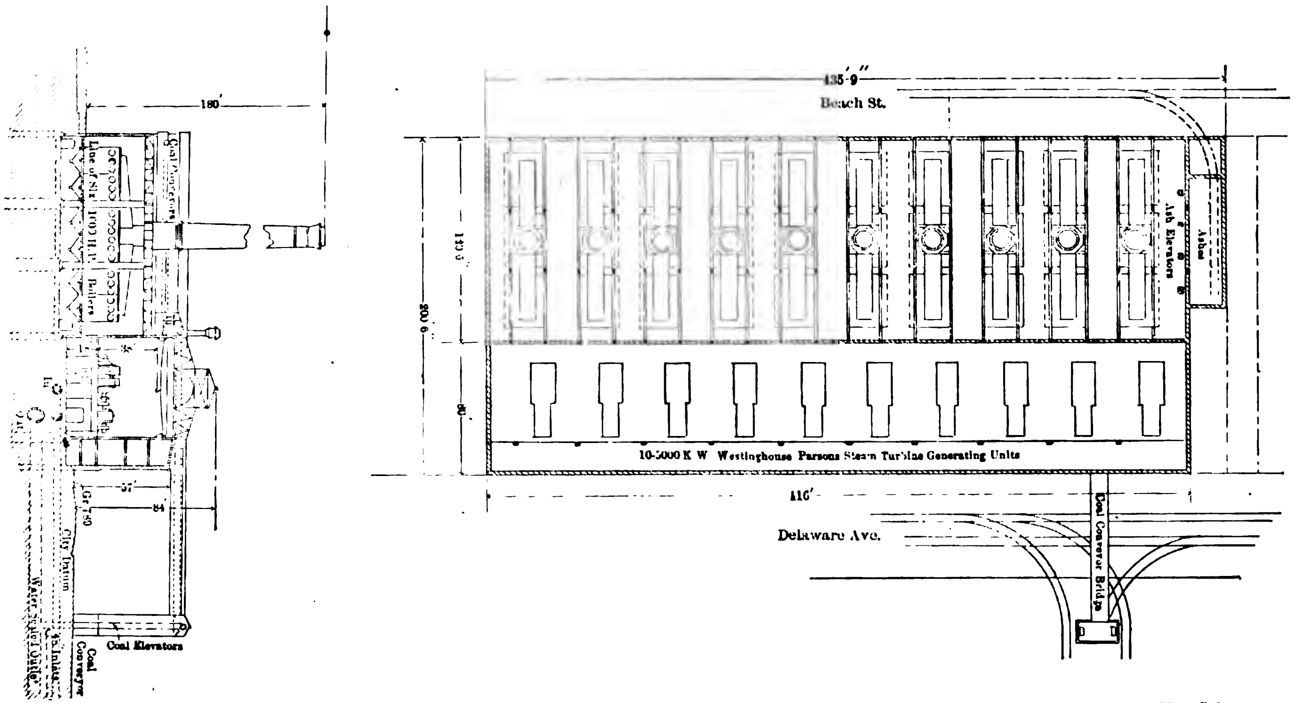

Fig. 30.—GENERAL ARRANGEMENT OF TURBINE POWER HOUSE—PHILADELPHIA RAPID TRANSIT CO., PHILADELPHIA, PA.
10 5000-kw. Westinghouse-Parsons turbine units—for underground railway system.

PRESIDENT LEACH: Gentlemen, the subject is open for discussion. The hour is getting late, I would like to hear from the members first, if they desire to talk. If we don't have talk enough from the members, there are a lot of gentlemen here tonight whom we don't see very often, and who, I think, are more or less interested in this subject, who probably will be able to tell us something. If we find that the thing is not coming along rapidly we will be glad to hear them say something, if they desire to. The only thing we will ask is that when they stand up they will not get so personal that there will be a rough house here. Now we will hear from the floor. Does any member want to ask any questions?

MR. DEAN: Mr. President, I did not mean to be the first one to speak, but inasmuch as I made some of the tests which are quoted tonight it may be proper that I should say something. I went to the shop of the Westinghouse Company at East Pittsburg and tested a 400 k.w. turbine, with the generator removed and a water brake put in its place, so that the results were obtained on the brake horsepower basis instead of on the electrical horsepower basis. I expect to return at almost any time to carry out a series with a generator, so that the results obtained will be on the electrical horsepower basis. I think that most persons who are interested in this subject have felt that perhaps the turbine is over-rated, and that too, much enthusiasm is manifested, but the truth of the matter is that there is not any too much. By that I don't mean to say that the turbine is just now everything that could be desired. It is not quite so economical as the best reciprocating engines, that is to say, at the rated load. We all know that within a comparatively few years the reciprocating engine has improved very much in economy by the study of small details, and we can easily believe that the turbine is going to be improved very much by further attention to small details. In fact, those who have kept the run of turbine economies have steadily seen a decrease in steam consumption. But even if we take the steam turbine as it now is, and compare it with the very best reciprocating engines, we will find that the curves of economy, when plotted, cross each other at somewhere about 75 per cent. of the rated load, and then again at about, I should say, 50 per

cent. over load. I might say that the best turbines surpass in economy the usual compound engine, but although the best turbines do not equal the best reciprocating engines at the rated load they do surpass them at some of the other loads, that is to say, the light loads and heavy loads. Of course the benefit of the turbine from small space occupied is very apparent, and uniformity of rotation is very apparent also. The ease of running turbines in parallel, as the saying is, when they have alternating generators, which they usually have, is greater, and there is no difficulty in running them in parallel with reciprocating engines.

President Leach: It is getting late, gentlemen. If you want a chance to talk you will have to be pretty quick.

Mr. Baker: Mr. President, I see Mr. Rice here. I also saw his name on the Rice & Sargent engine a little while ago. I think he might give us some interesting remarks on the steam turbine.

President Leach: We shall be pleased to hear from Mr. Rice.

Mr. R. H. Rice: I have had the good fortune to be connected with the building of some very economical stationary engines of reciprocating type, and also since then I have been fortunate enough to be connected with the development of the steam turbine. I therefore am able to view the subject from both standpoints. I think that Mr. Dean is quite right in saying that the enthusiasm which has been exhibited in the discussion of the steam turbine, and the adoption of the steam turbine by those people who have shown confidence enough in it to adopt it, has not been excessive in any way. I entered the turbine business with the opinion that there would be a field both for the turbine and for the stationary engine. I have been obliged to abandon that ground. I don't believe there is any place for the stationary engine. I think the turbine is bound within a very short time to entirely displace the stationary engine.

There is one thing I think should be clearly borne in mind, in discussing the questions of steam economy. The engine has always been rated on the basis of indicated horsepower. Now, there is no such thing as indicated horsepower in con-

nection with the steam turbine. Therefore we have three other units, all of which are used in describing tests, and great confusion is liable to result. We have the pounds of steam per kilowatt hour; we have the pounds of steam per electrical horsepower hour, which is simply multiplying the figure just spoken of, pounds of steam per kilowatt hour, by 746, and then we have the brake horsepower, which is still another unit and intermediate between that and the indicated horsepower, which is the one we are all accustomed to. Therefore it is very difficult, in comparing the figures which have been given, and which will be given in the future, to make comparisons, unless we bear these four different units clearly in mind.

I think at the present time there are enough turbines in operation to clearly demonstrate that the turbine is a thoroughly practical machine, that it has certain very great points of advantage entirely apart from the question of operation, such as the absence of oil in the condensed water, and therefore the ability to use that water over and over again, and, in cases of installations in cities at any rate, enabling a very large water bill to be saved; small floor space, which has been very clearly brought out here tonight; and the fact that the turbine, having fewer parts which require attention, is very much easier to operate.

Mr. Dean: Mr. President, I want to say one word more, and that is in regard to the use of the condensed steam over as feed water. That is very important in cities where you have to buy feed water, but it is no less important in bad water districts, as they have out West. You can readily see that by using the condensed steam over and over the trouble of incrustation of boilers is prevented.

President Leach: Any other gentleman?

Mr. Graham: Mr. President, I suppose everybody in this room knows who Mr. Westinghouse is, but I don't know that there are so many who know who Mr. Parsons is. Mr. Parsons happens to be an Englishman, who in the early eighties conceived the idea of this turbine and perfected it, and when his patents ran out, the British Government extended by act of Parliament the life of the patents for five years as he had not realized anything on his device. Those five years have elapsed.

Mr. Westinghouse came along, and he added a valuable feature to the turbine, making the mechanical center perfect, as our guest explained, by the oil suspension of the rotor. I think the members of the club are entitled to know that Mr. Parsons is a very clever engineer and prominent business man.

MR. WEBSTER: Mr. President, I would like to inquire of the speaker of the evening, through you, sir, what the probable effect of serious priming will have on the turbine. That is a question that some of the members present would like to hear answered.

PRESIDENT LEACH: Mr. Bibbins, can you answer that question?

MR. BIBBINS: I think the question can be best answered by giving the experience of the Hartford Electric Light Company. One evening during the approach of the peak load, a siphoning action took place on account of the overfilling of a boiler, and a large quantity of water went over into the turbine. It slowed the turbine down, and threw the turbine plant and the hydraulic plant, which operate in parallel, out of synchronism, leaving the entire city and power plant in darkness. The turbine was not even examined, but after the water had passed through into the condenser, it was again started up, and it was during that time that it carried the entire load on the system, amounting to about 22,000 k.w. It was started up within less than ten minutes from the time that the trouble occurred. The engineer did not know where the trouble was, whether it was on the line, at the hydraulic plant, or in his own plant. He simply took pot luck and started the turbine up again.

In other cases the same result has been obtained with water coming over from the boilers. This has happened once or twice at the Yale & Towne plant at Stamford, Conn. The turbine simply slows down, and as soon as the water passes through it recovers its speed.

No damage whatever has ever been noticed from entrained water, as far as I am aware, in any of our turbines.

PRESIDENT LEACH: Then the inference is that it does not suffer serious damage from water.

MR. BIBBINS: That is a question that I do not think has ever been raised before, and I cannot say offhand what the results

of experiments in this direction have been. I see no reason why the turbine should not start under load, if the pressure is brought up gradually; but will reply to the question more definitely in a communication after adjournment. As to the turbine being applied directly to driving line shafting, it could hardly be called the best form of motor for this purpose, on account of its rather high speed. The ideal method of applying the turbine to industrial works is through the motor drive, examples of which have already been cited. There appears to be no reason why the turbine should be applied directly to the line shafting, as so much greater flexibility can be secured through the use of the motor drive.

PRESIDENT LEACH: Does that answer your question, Mr. Webster?

MR. WEBSTER: Yes, sir.

PRESIDENT LEACH: Have you any more that you would like to ask?

MR. RICE: One thing more I would like to say. Mr. Dean has ventured on a prediction as to the future of the turbine, in which he stated that he looks forward to the turbine surpassing the results obtained by the very best reciprocating engines. I am glad to say that the results obtained from a turbine of another type from that which has been described tonight, but which will probably also be obtained by this same type in due time, have already surpassed the best reciprocating engines about three quarters of a pound.

PRESIDENT LEACH: Mr. Pomeroy, I guess you had better say a word or two to let them know you are here.

MR. POMEROY: I had just a few notes that I jotted down while on the train, and I think it will take only about three minutes to submit them. It was more in the line of accentuating some of the points that are not quite clear to us laymen, than anything else.

It is said that mankind needs not so much to be informed as to be reminded. In line with this sentiment I wish to very briefly touch on three or four points:

First. Why a greater vacuum than 25 inches of mercury cannot be advantageously utilized with reciprocating engines. The volume of one pound of saturated steam at 25 inches of

vacuum is 145 cubic feet, and for 29 inches, 709 cubic feet; at, say 28 1-2 inches, the volume is a trifle over three times as great as at 25 inches, as shown by the following table: —

VOLUME OF ONE POUND OF SATURATED STEAM AT ATMOSPHERIC PRESSURE AND AT VARIOUS VACUA.

Vacuum, inches of mercury	0 in.	25 in.	26 in.	27 in.	28 in.	29 in.
Volume of 1 lb. saturated steam in cubic feet	26.36	145	177.6	237	347.6	709
Comparative volume 0 inches of vacuum = 1	1	5.52	6.75	9	13.3	27

Not that reciprocating engines would not give better results with high vacuum than at low, but, owing to the greater volume of the vapor at the higher vacuum, the low-pressure cylinder, valves, passages, etc., would have to be made so large as to make the use of such high vacuum prohibitive, from a commercial standpoint, and wipe out the gain in steam consumption, possible from the higher vacuum.

For example, the low-pressure cylinder of the engines in the Manhattan Railway Power Station is 88 inches in diameter. If 28 1-2 inches of vacuum were to be employed, this cylinder would have to be increased to 153 inches in diameter, and the attendant parts correspondingly.

Per contra, the higher the vacuum with a steam turbine, the greater the economy.

Second. In general, superheat reduces initial condensation and has a larger volume than dry steam at same pressure. Accordingly, less weight of steam is required to fill the cylinder at any given cut-off, and the extra heat necessary to secure this increased volume is much less than would be required to produce saturated steam to fill the space, *i. e.*, about 10 per cent. increase in heat to secure a corresponding degree of superheat produced a gain of about 30 per cent. With steam turbines, every 50 degrees Fahrenheit of superheat shows a gain of about one pound in steam consumption, or 13 to 15 per cent. gain for from 140 to 150 degrees of superheat. Experiments prove that every one per cent. of cylinder condensation corresponds to about 8 degrees of superheat.

Assuming for the sake of illustration that the initial condensation of a given engine amounted to 20 per cent.—not an exaggerated case surely—the amount of superheat necessary to nullify this loss would be (8×20 degrees) 160 degrees. As the specific heat of superheated steam amounts to 0.48 b.t.u. per degree, 160 degrees would require 0.48×160 degrees or 76.8 b.t.u.

Approximately 1,100 b.t.u. are required to convert one pound of feed water, at ordinary temperature, into steam at the usual pressure. By adding to this 76.8 b.t.u. in the form of superheat, the expenditure of heat has been only 7 per cent., while the consumption of steam has been decreased by 20 per cent., or a saving of 220 b.t.u. In other words 76.8 b.t.u., rightly employed, prevents a loss of nearly three times as much heat.

Heat losses, *i. e.*, condensation, in the steam turbine, differ somewhat from similar losses in the reciprocating engine, as there are no cyclical variation in temperature, due to alternate presence of live and exhaust steam.

The losses in the steam turbines are mainly due to "skin friction" (to borrow a marine term) caused by the particles of entrained water in the steam. The late Dr. Thurston experimented with a 10-inch disk, and found that this loss amounted to one h.p. for every 275 drops at 200,000 revolutions per minute. Such losses are obviated in the steam turbine by the use of superheated steam.

Third: I have been making diligent search for the best obtainable performances of reciprocating engines and find the following tests on record:

They were made by Professor Schroeber of Munich, and Professor Webber of Zurich on Sultzer engines, equipped with poppet valves. No. 1 being a triple expansion four-cylinder of the horizontal type, with 59-inch stroke, rated at 3,000 i.h.p. at 85 r.p.m. No. 2 a triple expansion four-cylinder, vertical type, 51-inch stroke, 3,000 i.h.p at 84 i.p.m.

	No. 1.	No. 2.
Boiler pressure pounds per square inch....	188	189
Superheat, degrees Fahrenheit	230 degrees	236 degrees
Temperature, steam, degrees Fahrenheit ..	606 "	613 "
Load, i.h.p.	2.860	2.908
Pounds steam per i.h.p. hour............	8.97	9.41
*Pounds steam per k.w. hour............	14.25	14.90

*Based on a combined efficiency of engine and generator of 85 per cent.

These results represent what we might call "doing laboratory stunts" with the reciprocating engine, and hardly representative or obtainable in commercial practice. Nevertheless, similar results have been recently obtained with the most modern type of steam turbine, and shows what can confidently be expected in the near future.

Fourth: The steam consumption of the average locomotive amounts to 35 pounds per i.h.p. hour; equating for steam consumption per k.w. hour at an efficiency of 90 per cent. we have 52 pounds per k.w. hour.

A power station, equipped with modern steam turbines, producing power at the generator, at the rate of 17 pounds of steam per k.w. hour, with an efficiency of 7.24 per cent. from generator switchboard to motor axle, the result would be an equivalent steam consumption of 23.4 pounds per k.w. hour. Comparing this with the 52 pounds for the steam locomotive, as mentioned, we have a saving of 55 per cent. over the steam locomotive. These figures show one of the many points where electricity will score over the steam locomotive, as the near future will undoubtedly demonstrate to the satisfaction of the most skeptical.

Mr. Manning: Mr. President, in the comparison with locomotives just referred to is the turbine there mentioned one working with superheated steam or condenser?

Mr. Pomeroy: Both with superheated steam and condenser.

Mr. Manning: On the locomotive?

Mr. Pomeroy: No, in a stationary power plant.

Mr. Manning: What I am getting at is a comparison between the turbine and the locomotive on which we cannot use condensers and superheaters.

Mr. Pomeroy: They are using the superheat now.

Mr. Manning: I mean ordinarily. Will the turbine, worked under the same conditions, give any such efficiency as 60 per cent?

Mr. Pomeroy: I think that the question is hardly in point, because we are trying to compare what it is possible to gain by having an electric power station operating under the most economical method, transmitting the power so generated to the motor axle, with the present method of operating the average railroad by steam locomotives.

MR. MANNING: I don't know that I am quite understood. What I am getting at is the application of this turbine to the locomotive. Some day I presume that will be attempted, if it has not been tried already. My idea was to find out whether there was any such comparative efficiency between the two types, used without condensers or special superheaters, as was found with the engines equipped with those improvements. You know that we are particularly interested in locomotives, here.

MR. POMEROY: It doesn't seem to me that it is possible, at the present state of the art, at least, to utilize the turbine on a locomotive, for, as I understand it, the turbine has to start without a load, while the locomotive has to start under maximum load. Unless some remarkable developments or changes are made, it does not seem within the near future very possible to see a steam turbine used on a locomotive.

MR. BAKER: Mr. President, I think I can get at that very nicely by using an electromotive. We have Mr. Pierce here this evening. Maybe he would like to tell us about it.

PRESIDENT LEACH: We will be pleased to hear from Mr. Pierce of the General Electric.

MR. PIERCE: I have listened with a great deal of interest to this paper, which has been so ably presented here by our friend. I have simply come here as a listener, and have really nothing to say to you. I do feel, however, that the turbine offers an opportunity that we have never had before. In other words, it really makes feasible and possible to-day electrification of a road from here to New York, which really was not possible five years ago, simply by reducing the number of stations and also reducing the original capitalization necessary to do this work. That is really what it means from that standpoint. I have come here just to listen. I have not really anything to say. I represent the General Electric Company. We have a turbine of our own, which we hope at some future meeting to tell you a little more about.

MR. WEBSTER: Mr. President, one of the speakers mentioned as a probable fact that this type of turbine would not start under load. If that is so, we should know it. I would like to ask the speaker of the evening if the Westing-

house-Parsons turbine is adapted to connect direct to a line shaft for mill work, where it is quite the thing to connect large units of power for this purpose, doing away with belting. If this has been done, I would like to know it, as that question has been asked of me by one of our guests.

PRESIDENT LEACH: Will any gentleman who is in a position to tell us about steam turbines state whether it is possible to start a steam turbine under any kind of load, to answer the question asked by Mr. Webster?

MR. BIBBINS: Do I understand that the question is whether the turbine can start under load?

PRESIDENT LEACH: Yes.

MR. BIBBINS: Or whether it is applicable to the driving of line shafting?

PRESIDENT LEACH: Yes, whether the steam turbine can start under a load, or whether it would have to be started without any load.

MR. BIBBINS: In reference to the ability of the turbine to start under load, I find that, as a result of tests upon turbines at our shops, it has been found that the starting torque is fully three or four times that of the full load running torque, and that no particular precautions are necessary in thus starting the turbine under load. It would, of course, be unwise to start any form of steam engine abruptly without first warming it up to a certain degree; for instance, a steam locomotive, although the throttle may be opened wide within a period of a few seconds, is not started cold, as the cylinder, due to its heavy lagging, retains its heat from previous runs. The deleterious effects which may result from too immediate admission of steam are found to be much less severe in the turbine than in the case of the engine. In the former, the water condensation simply acts as a brake, reducing the speed of the turbine until a running temperature has been attained; while in the latter, unless full precautions are taken to carry away this water, cracked cylinder heads or even total destruction of the engine may be a possible result.

PRESIDENT LEACH: Is there any other gentleman who would like to speak on that question?

MR. GRAHAM: Neither of the speakers tonight has told us the weight of these turbines per horsepower. In Reading, Pa.,

they have just produced a 6-cylinder opposed type engine, of 40 horsepower, and the weight of it is five pounds per horsepower. I notice my friend Pierce says that some day we will be going down to New York by electricity in place of steam. Well, the electrical companies will have to take a right hand turn and get away from the practice of the railroads, because they have altogether too much weight.

President Leach: Any other gentleman like to say anything? I would ask Mr. Bibbins if he has anything to say in closing?

Mr. Bibbins: I may say that there seems to be a little misunderstanding about our recognition of Mr. Parsons' work in developing the type of steam turbine described. It would seem that sufficient recognition is evident in the use of the hyphenated term, Westinghouse-Parsons.

A point of evident interest in this discussion is the comparative merits of turbine and piston engine. The discussion can, of course, be carried to any extent, involving much theoretical speculation, but I wish simply to point out one fact. If the turbine is allowed to operate under the conditions to which it is best suited, it will show far better economy than is usually thought possible. I have not the exact figures at hand, but I understand that some builders of the Parsons' turbine have guaranteed between 10 and 11 pounds per electrical horsepower hour, and they have actually obtained 10.44 pounds per electrical horsepower. That is, of course, with high superheat. Now, if we assume a combined engine and generator efficiency of 85 per cent.,— which is a very widely accepted figure for a reciprocating engine unit,— this brings the steam consumption of the turbine between 9 and 9 1-2 pounds per internal horsepower. I believe that I am correct in saying that there are very few engines,— even though operating under conditions which best suit them,— that can show this economy. As one of the speakers has said, it is difficult to compare engine-indicated horsepower and turbine-indicated horsepower. The only means of arriving at that comparison is to assume for the turbine the conditions which we are accustomed to assume for the engine, and we then obtain a figure which is really in terms of engine performance,— but, nevertheless, a figure

which gives a direct comparison between engine and turbine.

President Leach: Would any of the other speakers like to say a word in closing? If no other gentleman desires to speak on the subject, we will declare it closed. The subject for the April meeting is to be "Specifications and Requirements of Materials Used by Railroads." That may not be the exact wording as it will be advertised, but it is to that effect. We expect that Mr. James E. Howard, from the Watertown Arsenal, and Mr. Dudley, Chemist of the Pennsylvania Railroad, will be here and talk to us on that subject.

Mr. Dean: Mr. President, I wish to propose a vote of thanks to the author of the paper of the evening.

(The motion was seconded and adopted. The Club then adjourned.)

CONSTITUTION.

ARTICLE I.

NAME.

The name of this association shall be the NEW ENGLAND RAILROAD CLUB.

ARTICLE II.

OBJECTS.

The objects of this Club shall be, first, to promote knowledge on all matters relative to the construction and management of railroads and their equipment, which may be brought before the Club for consideration and discussion; and, second, to encourage social relations among its members.

ARTICLE III.

MEMBERSHIP.

Amended January and March, 1901.

The membership of this Club shall consist of persons connected with the construction, operation, or maintenance of railroads or railways, or of their equipment; of civil, mechanical, or electrical engineers; and of students of engineering in engineering colleges. Applicants for membership may be admitted by a majority vote of the Executive Committee, and the payment of the initiation fee and the annual assessment.

Any member may be expelled by a two-thirds vote of the members present at any regular meeting upon the recommendation, made by the majority vote of the Executive Committee, that the best interests of the Club may be served thereby.

ARTICLE IV.

OFFICERS.

The officers of this Club shall consist of —

(1) A President, who shall preside at all meetings of the Club and perform the duties usually pertaining to the presid-

ing officer. He shall also be a member and chairman of both the Executive and Finance Committees, and shall approve all bills before payment. He shall not be eligible for two successive terms.

(2) A Vice-President, who shall in the absence of the President perform all the duties required of that officer.

(3) A Secretary, who shall keep a record of the proceedings of the Club; notify all officers of their election and committees of their appointment; issue notifications whenever directed by the President; collect all dues, depositing same with Treasurer.

(4) A Treasurer, whose duty it shall be to receive all funds, pay all bills when approved by the President, and submit his accounts to the Club at the annual meeting, or oftener if required.

Article V.

EXECUTIVE COMMITTEE.

An Executive Committee, consisting of ten members (including the President), shall be elected at each annual meeting and serve for one year, or until their successors shall have been elected, whose duties shall be to receive all subjects for debate and bring them before the Club at such times as they may judge most beneficial for their discussion. They shall also vote on all applications for membership, and shall act on all matters properly referred to them. A quorum shall consist of three present and voting.

Article VI.

FINANCE COMMITTEE.

A Finance Committee, consisting of three members (including the President), shall be elected at each annual meeting, whose duties shall be to have a general supervision of the financial affairs of the Club and to audit the books and accounts of the Secretary and Treasurer.

Article VII.

SUBJECT COMMITTEE.

(1) A Standing Committee on Subjects, consisting of ten members, exclusive of officers and members of Executive and Finance Committees, shall be appointed by the President, the membership to represent, as far as possible, the different branches of railroad service, and the term of office to end with the annual meeting.

(2) This Committee to be called together by the Secretary, at the request of the President, and present to the Executive Committee a list of subjects for discussion.

(3) The Secretary of the Club shall, without voice, act as secretary of this Committee.

Article VIII.

MEMBERSHIP COMMITTEE.

(1) The President at the annual meeting, or as soon thereafter as possible, shall appoint a Committee on Membership, to whom all applications shall be referred, and who shall report to the Executive Committee their recommendations.

(2) This Committee shall consist of five members, of which one each shall be a member of the Executive and Finance Committees. Three members shall constitute a quorum.

Article IX.

PUBLICATION COMMITTEE.

The President, at the annual meeting or as soon thereafter as possible, shall appoint a Publication Committee, consisting of the President, Secretary, Finance Committee, and one other member, who shall have entire charge of the publication of the Club's proceedings and exchange of same with other clubs.

Article X.

NOMINATING COMMITTEE.

At the meeting preceding the annual meeting, a Nominating Committee of five shall be appointed by the President, who shall present at the annual meeting a list of names for each office to be filled; and the nominee receiving the highest number of votes for each office shall be declared elected.

Article XI.

ELECTION OF OFFICERS.

(1) The officers of the Club (except the Secretary) shall be elected by a majority ballot at the annual meeting, and shall hold their respective offices for the term of one year, or until their successors are chosen.

(2) The Secretary shall be appointed by a majority vote of the Executive Committee as early as possible after the annual election, and his term of office shall terminate with the appointment of his successor. The Executive Committee shall have power, by a two-thirds vote of all its members, to remove the Secretary and appoint his successor at any time.

The salary of the Secretary shall be decided by a majority vote of the Executive Committee.

(3) Any vacancy in office which may occur after the annual election may be filled at any regular meeting of the Club.

Article XII.

AMENDMENTS.

This Constitution may be amended at any regular meeting of the Club by vote of two thirds of the members present and voting, said amendment having been proposed in writing and read at a previous regular meeting.

BY-LAWS.

Article I.

TIME OF MEETING.

Section 1. The regular meeting of this Club shall be on the second Tuesday of each month (except June, July, and August) at eight o'clock P. M.

Sect. 2. The annual meeting shall be held on the second Tuesday in March.

Sect. 3. The President may call special meetings at such other times as he may deem expedient, and shall do so upon the written request of at least twenty-five members.

Article II.

QUORUM.

At any regular or special meeting, twenty-five members shall constitute a quorum for the transaction of business.

Article III.

PRESIDING OFFICER.

In the absence of both the President and Vice-President, a presiding officer *pro tem.* shall be chosen by the meeting.

Article IV.

DUES.

Amended May 13, 1902.
Amended February 12, 1904.

The Initiation Fee shall be five dollars, which shall include the dues until the next annual meeting, and the Annual Dues thereafter shall be two dollars, payable in advance on the second Tuesday in March of each year, of which one dollar shall be in payment of one year's subscription for the printed proceedings of the Club at the published price. Members whose dues remain unpaid at the regular meeting in May following shall forfeit membership and

[illegible] rights and privileges of the Club. Nothing in the provisions [illegible] shall prevent delinquent members from [illegible] new application, and such application shall be subject to the same action as in the case of application of new members, [illegible] the exception of the Initiation Fee.

Article V.

The order of business shall be as follows: —

1. Approval of the minutes.
2. Reports of committees.
3. Unfinished business.
4. New business.
5. Election of officers.
6. Appointment of committees.
7. Discussion of subject announced.
8. Announcements.
9. Adjournment.

Article VI.

PUBLICATIONS.

Section 1. The proceedings or such portion thereof as the Executive Committee shall decide, of the regular meetings of the Club, shall be published (standard size, 6 x 9 inches) and mailed to the members of the Club and to members of other similar Clubs with whom exchange is made.

Sect. 2. The published proceedings of the annual meeting of the Club shall contain the Constitution and By-Laws of the Club, together with a list of the officers and members of the Club.

Article VII.

AMENDMENTS.

These by laws, or any of them, may be suspended or amended at any regular meeting of the Club by a vote of two thirds of the members present and voting, said amendment having been proposed in writing and read at a previous regular meeting.

LIST OF MEMBERS.

Adams, F. D.,
34 St. James Place,
Buffalo, N. Y

Adams, George F.,
G. Foreman, B.&M.R.R. Car Shops
Nashua, N. H.

Adams, T. W.,
N. Y., N. H. & H. R. R.,
Norwood Central, Mass.

Adams, Wm. H.,
Atlantic Works,
East Boston, Mass.

Aiken, O. L.,
Care B. & M. R. R.
Lawrence, Mass.

Akers, George J.,
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Aldcorn, Thos.,
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Alford, Frederick,
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Allen, Prof. C. F.,
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Andrews, W. H.,
Mgr. Pratt & Lambert
Buffa'o, N. Y.

Appleyard, William P.,
Care Pullman Co.
Chicago, Ill.

Archibald, Frank B.
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Arey, S. R.,
G. Foreman, B.&M.R.R. Car Shops,
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Armstrong, Chris,
Care B. & A. R.R.,
Allston, Mass.

Ashton, Albert O.,
Care of Ashton Valve Company,
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Ashton, Frank G.,
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Civil Engr., N. Y., N. E. & H. R. R.,
Readville, Mass.

Austin, Frank P.,
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So. Lawrence, Mass.

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Suncook, N. H.

Baker, Charles F.,
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Baker, Edwin H.,
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Barbey, F. A.,
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Barr, James C.,
70 Kilby St.,
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Bartlett, A. V.,
Union Station, B. & M. R. R.,
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Bartholomew, Wm. S.,
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Bartlett, H.,
S. M. P., B. & M. R. R.,
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Barton, John H.,
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Bell, C. C.
American Vulcanized Fibre Co.
No. Cambridge, Mass.

Bellows, Chas. F.,
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Berry, Arthur O.,
Div. Foreman B. & A. R.R.,
Rensselaer, N.Y.

Berwick, Robert.
81 Chapman St,
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Bicknell, George H.,
10 Isabella St.,
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Bigelow, Chas. H.,
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Care of L. O. Chase & Co.,
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Conductors' Room, B. & A. Depot,
Boston, Mass.

Blanchard, W. A.,
American Steel Casting Co.,
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Bodwell, G. Arthur,
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Salem, Mass.

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Boutwell, Roland H.,
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Brady, J. B.,
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Brady, J. T.,
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Brownell, F. G.,
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Buchannan, E. G.,
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Burnstine, Albert,
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Butler, Alton G.,
Alva-Lee Co.,
Florida.

Butler, L. M.,
Auburn, R. I.

Butterfield, W. R.,
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B. & A. R. R.,
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Carr, Fredk. A.
Chief Clerk, M.C.B., B. & M. R.R.
Boston, Mass.

Casey, Fred A.,
Care of Ashton Valve Co
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Chain, Elmer E.,
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B. & A. R.R., So. Terminal Station,
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Chamberlain, J. T.,
Master Car Builder, B. & M. R. R.
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Rutland, Vt.

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M. C. B., Central Vt. R. R.,
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B. & A. R. R.
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Conn, Charles F.,
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G. Foreman, B.&M.R.R. Car Shops,
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Foreman Painter, B. & M. R. R.,
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Hillburn, N. Y.

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Keene, N. H.

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Clerk, S. M. P., B. & M.,
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Allston, Mass.

Fuller, C. E. Jr.,
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Care D. E. Davis, B. & M. R.R.,
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For Painter, N. Y., N. H. & H. R.R.,
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Care of Flood & Conklin Co.,
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Care of Latrobe Steel Wks.,
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Goodwin, Chas. E.,
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Gray, Peter,
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Air Brake Inspec., B. & M. R. R.
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Keith, Eben S. S.,
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Rutland, Vt.

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New England Railroad Club

April 12, 1904.

SUBJECT FOR DISCUSSION:

THE USE OF IRON AND STEEL FOR RAILROAD PURPOSES.

Paper by Mr. JAMES E. HOWARD.

E. L. JANES, SECRETARY, SOUTH TERMINAL STATION, BOSTON, MASS.

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The regular meetings of this Club are held at Pierce Hall, Copley Square, corner of Dartmouth Street and Huntington Avenue, Boston, on second Tuesday of each month, excepting June, July, August and September.

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A REGULAR MEETING of the New England Railroad Club was held at Pierce Hall, Copley Square, Boston, on Tuesday evening, April 12, 1904, at 8 P.M., President W. B. Leach in the chair.

The following members registered: —

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THE PRESIDENT: You have heard the names of the gentlemen as the Secretary has read them. They were elected members of this Club by the Executive Committee this evening. There is a report on the appointment of Committees.

THE SECRETARY: Your President has made the following appointments on the several committees: *Subject Committee.*—T. B. Purves, Jr., Chairman; Prof. Gaetano Lanza, John M. FitzGerald, E. G. Desoe, J. T. Brady, E. T. Millar, George S. Webster, Elmer H. Morse, J. B. Laurie, E. K. Turner. *Publication Committee.*—W. B. Leach, Chairman; E. L. Janes, B. M. Jones, Henry Bartlett, Frank A. Barbey. *Membership Committee.*—F. B. Smith, Chairman; C. W. Sherburne, Prof. G. F. Swain, A. J. Fries, C. H. Wiggin.

THE PRESIDENT: Does any member present know of any new business, or have anything to offer? If not, we will proceed to the paper of the evening.

We will listen this evening to "A Talk on the Use of Iron and Steel for Railroad Purposes," by Mr. James E. Howard, Engineer of Tests at the Watertown Arsenal. Gentlemen, I take great pleasure in introducing Mr. Howard.

A TALK ON THE USE OF IRON AND STEEL FOR RAILROAD PURPOSES.

By JAMES E. HOWARD.

ENGINEER OF TESTS AT THE WATERTOWN ARSENAL.

Mr. President and Gentlemen of the New England Railroad Club:

Our knowledge of the strength of materials is acquired chiefly by means of the testing machine. Those physical properties — the elastic limit, tensile strength, elongation and contraction of area and other properties — have been determined with different grades of iron and steel, and we are reasonably familiar with the range in values which may be expected according to the chemical composition, modified by the heat or mechanical treatment to which the metal has been subjected. We know that the range in strength is very great with steels of different composition, and also that a wide range is possible in

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the same steel, due to the manner in which it has been heated and cooled, or the manner in which it has been worked. By skillful manipulation, predefined values may be attained in each of the properties which have been enumerated, and certain combinations of those properties are likewise attainable. Specifications governing the strength of materials are established for the purpose of obtaining such values in the physical properties of iron and steel as the conditions of service are thought to require. Much care and attention are not infrequently bestowed upon the efforts made to secure the desired qualities.

From the general rigorous nature of most specifications, and the large volume of testing constantly going on, it would appear that good metal was to be found only between certain sharply defined limits, and that a concurrence of opinion prevailed respecting the means by which it was to be secured. But exacting specifications carry with them the idea that the subsequent use of the material will be under well-known and well-defined conditions. It must be admitted, however, that service conditions are frequently so varied and complex as to baffle an exact definition of the loads which come upon the material, and this is particularly true where moving masses, or live weights, so called, are responsible for the principal stresses.

However great the difficulties in general engineering practice, railway service doubtless presents an unusual number of perplexing questions of this nature. Instead of judging from cause to effect, it would seem necessary in some instances to reverse our train of thought and endeavor from the evidence presented in the failure of material to retrace to their origin the causes which contributed to that end.

To pass at once from a general consideration of the problems attending the use of constructive material, some remarks will be made upon the specific use of steel and its behavior in the form of rails.

The ordinary tensile and drop tests are relied upon to indicate the quality of metal present, and the acceptance of the material will depend upon the results of those tests, aided by an inspection for physical defects. The metal having, in the tests, displayed the strength and ductility called for by the specifications, it is accepted and put into service.

Up to this time the steel is subject to critical inspection, but after reaching the track that appears to be somewhat relaxed. The metal is then left in some measure to its own resources to maintain its integrity, and whether it is overworked in its endeavors to do this is not always known. The definition of the severity of the strains imposed upon a rail in the track is not easily accomplished, it is not a computable problem.

The moment of resistance of the rail for transverse loads, the magnitude of the wheel pressures and the spacing of the ties, all being known, still these data are not sufficient to accurately define the maximum stresses in the rails. The unknown factors of the case are the behavior of the ties and ballast. They yield, and to such an extent that a direct experimental determination of the strains in the rail in the track is necessary, measuring on the metal itself the effects of the wheel pressures.

Some preliminary tests of this kind were made on the Boston & Albany, in which the extension or compression of the metal in the base of the rail was measured as the different wheels of a locomotive passed over the place of observation. The strains thus developed are easily expressed in stresses per square inch, and occur alternately in a tensile and compressive direction according to the position of the wheels; that is, both the head of the rail and the base are alternately strained in tension and in compression, and the measurements indicate how many pounds per square inch they are equivalent to. Subsequently, a series of observations was made on the C. B. & Q., and then others were made on the Pennsylvania, and again on the Boston & Albany, the latter at a time when the ballast was in a frozen state.

The range in conditions present in these experiments included rails from 60 lbs. to 100 lbs. section, on cinder, gravel or stone ballast, and with several types of passenger and freight locomotives.

The maximum fibre stresses observed ranged generally from 10,000 to 17,000 lbs. per square inch tension, under the weights of the driving wheels; attaining in one instance a stress of 19,540 lbs. per square inch.

The wheel pressures were highest in the passenger engines, and the effect on the track was greatest under them.

A tie was removed from under a 100-lb. rail, which increased the fibre stress from about 10,000 lbs. per square inch to above 18,000 lbs. per square inch.

The drivers strain the rail most, since the total weight on them is much greater than on the other wheels.

Taken ton for ton, however, the first pilot wheel generally strained the rail more severely than the drivers, and in one case it was even found that the pilot wheel strained the metal in the rail as much as the drivers, notwithstanding the weight on the pilot wheel was less than one-half that on a driver.

The reason for this difference in effect is due to the sharper bend in the rail under the leading wheel than those found under the succeeding wheels, where the conditions of loading somewhat resemble a continuous girder, the wheels in front and rear holding the rail down. These values, representing the range in fibre stresses, are for engines at rest on the track or moving very slowly.

Greater stresses should be expected when running at high speeds. In view of the fact that so few rails fracture in service, it is inferred that fibre stresses of say 15,000 to 20,000 lbs. per square inch can be sustained for a considerable number of repetitions by the grades of steel at present used in rails.

The examination of a splice bar on a 70-lb. rail showed a fibre stress of 22,000 lbs. per square inch in tension. The frequent renewals of splice bars point to this value as the limiting stress in this class of material. It should be remarked that the stresses which have been mentioned are mean results of observations made on a gauged length of five inches, taken along the rail or splice bar, and that the maximum stresses, at the section where the bending moment is greatest, would give results above those quoted. In other words, the metal is strained somewhat higher than our figures show.

The influence of the kind of ballast used was less conspicuous on the development of strains in the metal of the rail than on the general yielding and depression of the track as a whole. In respect to rigidity of the track against bodily depression, the highest rigidity was displayed on the gravel ballast, next to which came the stone ballast, and finally cinder, which was generally the most yielding of the three. It so chanced, how-

ever, that observations on one weight of rail, a 70-lb. section, showed greater depression with the rock ballast then with the cinder. There is a slight general depression of the road bed in the vicinity of the locomotive, which, comparatively speaking, always stands in a hollow. This local depression in the Hawthorne yard of the C. B. & Q., where cinder ballast was used, was perceptible on the sides of the track eight and one-half feet away from the engine.

While these two classes of phenomena — fibre stresses in the metal and general depression of the track — were not developed with equal relative prominence, the evidence favors the conclusion that diminished depressions will be attended by diminished fibre stresses, that is, the effect of a given load on the rail will be less severe in a comparatively rigid track than in the case of a more yielding one.

Passing now to a few remarks on the local effect of wheel pressures and the abrasion and wear of the steel, a high wheel pressure obviously has a tendency to cause flow in the head of the rail, and this will be accomplished more readily with a steel of low elastic strength than with a stronger metal, referring now to cases of permanent set, elastic displacements being nearly, if not quite, the same for the same load among the different steels without regard to grade.

When permanent flow occurs it takes place chiefly in lateral directions. There is a certain alternation in the stresses on the heads of the rails taken longitudinally, the driving wheels tending to crowd the metal backward, all other wheels of the train tending to crowd it forward. Promoted by the presence of grit, and assisted also by inequalities in the wheels and rail, the result is a more or less rapid wearing down of the metal of the head. This process of abrasion and wear is attended with a loss in ductility of the metal at and immediately below the running surface of the head. This exhaustion of ductility induces a brittle fracture when the rail is broken transversely with the head on the tension side of the bend. It is not recalled that any worn rail, thus fractured in the testing machine, has failed to display a state of brittleness with some apparent loss in strength, certainly none that has shown by the presence of a fin along the side of the head that cold flow had occurred in

service. It is not to be assumed that a rail originally tough will remain so after wear. The presence of a fin along the side of the head should be taken as evidence that the metal was originally tough, but is not so now. A soft rail is deficient in strength at the beginning. It soon becomes brittle by cold flow, and may then possess less strength than it had originally. This effect is confined to a shallow depth of metal, and if this is planed off the rail will thereupon resume its tough qualities. Its toughness may also be restored by annealing. Restoration by annealing shows that it is not by reason of incipient cracks next the running surface that brittleness arises, since no effacement of such cracks would take place during this operation.

It is immaterial whether the metal below the affected zone is inherently tough or brittle; there is generally a sufficient depth of brittle metal at the head of a worn rail to cause the remaining part of the cross section to fracture in a brittle manner, if rupture occurs. A worn rail bent with the base on the tension side may be expected to display its original toughness, and, if soft steel, bend over a considerable angle without fracture. Exhaustion of toughness may result from other causes than wheel pressures. A brittle fracture in a rail has been witnessed which was caused by the upsetting of the metal in the flange by contact with a spike. The upsetting of bolt holes in the web is a step in the direction of ultimate rupture. Some injuries from their position, however, are less harmful than others.

Usually it is quite an easy matter in the fractures of steels to tell where they began and the directions in which they traverse the metal. A clearly defined radiant appearance is commonly present in granular fractures, and the centre of radiation marks the place where rupture began.

Thus upon inspection of a fractured surface we are led to take note of the place where the fracture began, and from this information may reach an accurate opinion of the cause of rupture.

I have some photographs of rails, illustrating where rupture began. These are marked with an X. One is at the outside surface of the head, another at worn section of a spike, at the flange of the base. These other two fractures similarly show

rails which fractured, beginning at a point at the running surface of the head.

Here is still another photograph, showing a tough rail which has seen considerable service, but the top surface of the head has been planed away to a depth of about ⅛-inch. It will now bend equally well with the head in tension or the base in tension. Portions of the head were cut off by a planer, one part was annealed, another part had the top surface planed away, like the intact rail, and those bent well. The lower part of this first cut shows a section of the head bent, or the result of an attempt made to bend it, in the natural state, as it came from service, and that broke in a brittle manner, without any display of ductility. If any portion of the affected metal remains unplaned away, that is, if you cut squarely across the top of the head, and allow a little metal on the sides which have been affected by cold flow to remain, it is practically the same as if you had left it all there. There will be a brittle fracture. The lower cut shows a fracture which was made with the head in tension. There is no appreciable deflection before rupture. It also shows the same rail bent with the base in tension, and the bending goes on very well. From the inspection of those photographs you can readily see where the fractures began, and the same can be shown in other classes of material.

As an illustration of what is possible, to judge from fractures, here are a few pieces of some hardened bicycle balls, which fractured when loaded between hardened steel surfaces. This is one quarter of a ⅜-inch bicycle ball, and it is possible by careful inspection of those two surfaces to tell where each fracture began and which fractured in advance of the other, although when the ball was tested for destruction it burst into fragments quite suddenly. I would like to impress the fact, that it is possible to tell where a fracture begins by very simple means, and you can tell also which was the primitive fracture and which was the secondary one.

As simple, direct and reliable as this method is of ascertaining the cause of fractures from the evidence on the fractured surfaces, it is difficult to find instances of its practical application. In the report of the Committee of the English Board of

Trade on the St. Neot's disaster, which occurred in December, 1895, while many illustrations were presented, there were none of the fractured surfaces, notwithstanding one of the rails was broken into seventeen pieces. The omission of such illustrations would seem to indicate that the value of this evidence was overlooked. Views of the fractured surfaces of this rail, furnished by an independent investigator, showed that ruptures had their origins at the worn running surface of the head. - There is no mystery connected with fractures which begin at this surface.

As to the quality of the metal suitable for a rail, it is quite essential that a strong steel be employed. The problem is how to resist the wheel pressure against bending the rail, and to resist local flow at the place of contact of the tire and rail head.

The tranverse strength of the rail is raised in a general sense by increasing its sectionaal area, or weight per yard. Its local resistance against wheel pressures is augmented by using steel of higher physical properties. A high elastic limit and tensile strength is not coupled with the ductility usually present in mild steel, and hard, strong rails should not be expected to bend so much as the softer, weaker ones, *i. e.*, when both are new. But the softer metal loses it ductility by local flow under the wheel pressures, readily so by reason of low strength, and soon becomes brittle, and with brittleness and low strength associated these qualities joined place its value below the stronger rail. Further experimental data are needed to demonstrate the relative effect of high wheel pressures on steels differing in initial hardness, and to ascertain what grades show minimum depreciation in ductility as the result of abrasion and wear. In that sentence I have referred to the need of knowing, ascertaining experimentally, whether the hardest rails in service are more brittle after having been in use than they were originally, whether it is possible to get any grade of steel which admits of abrasion and wear without becoming exhausted in its toughness at the running surface of the head. We, of course, can remove some of the metal and leave its good qualities remaining ; we can grind it off with an emery wheel ; but I do not know whether it is possible to have any steel, hard or soft,

which does not become a little more brittle after the abrasion and wear incident to ordinary wheel pressures. It is certainly so in all cases that I have had the privilege of observing, whether the wheel pressures were light or heavy.

We occasionally hear of co-efficients of quality for steel rails; one proposed criterion being the product of the tensile strength and the percentage of elongation, another taking the product of the square of the tensile strength by the elongation. The practical value of either co-efficient is probably open to discussion. There is obviously quite a difference between the two, whether you take the product of tensile strength and elongation, or square one and let the other one be the natural number. It seems safe to say, however, that high elastic strength must be provided in order to successfully resist high loads, repeatedly applied, and that high tensile strength is also desirable. The part played by elongation is not so easily understood, at least in the case of alternate stresses, where this property is hardly called into action by the conditions of service.

Passing to the subject of axles, with an axle there is a wider latitude in the choice of physical properties than in the case of a rail, provided the question of weight is ignored, but with due regard to economy of material the choice is limited to the stronger grades of steel.

It has been thought that a pre-eminently safe metal was to be found in the softer, and initially very ductile, grades of puddled iron. The drop test, on new material, may have encouraged this belief. But initial ductility in an axle, like that of a rail, does not insure the retention of this property after prolonged and severe service conditions.

A soft iron axle is easily ruptured by repeated alternate loads of low magnitude, which would cause no appreciable deterioration in a high grade steel axle. Two hundred million repetitions of load are not unusual in the life of some axles. To attain so great a limit of endurance the maximum fibre stresses must be kept very low, particularly so if an iron axle of low elastic limit is used.

An exceptional overload, such as might result from derailment, should be met by adequate latent toughness to endure bending without breaking, but it must be borne in mind that

repeated alternate stresses are competent to rupture any grade of iron or steel with hardly an appreciable display of ductility. The stress which will promptly accomplish this result is lower for a weak metal than for a strong one.

It is a difficult question to decide how it is best to obtain high physical properties, whether by chemical composition, heat, or mechanical treatment, but it is quite certain that high strength must be present to resist high stresses.

Illustrating the effect of repeated stresses on different grades of steel, between 300 and 400 experimental bars have been tested at the Watertown Arsenal, all grades of steel from soft to hard, and without exception it has been possible to rupture all of those bars without — well — with hardly a measurable display of elongation.

The mechanical work necessary to rupture different grades of steel is not strikingly unlike in amount, whether a mild steel or a hard steel is ruptured. In round numbers about one thousand foot-pounds of mechanical work will rupture a cubic inch of steel, when ruptured in tension, by a single application of force. Under repeated stresses the metal may endure hundreds of thousands or millions of foot-pounds work without rupure.

Under a force once applied a piece of steel one inch long may elongate five hundredths of an inch in hard steel, or it may elongate two tenths of an inch in soft steel. That is about the range, from 5 per cent. to 20 per cent., which we commonly meet in structural material.

Under repeated stresses the aggregate elastic extensions may reach a total distance of three miles. From this point of view, the question of demanding a few hundredths of an inch elongation, more or less, in the specifications, is not a very impressive affair.

Here is a piece of a wrought iron axle, taken from the inner end of the journal. It contains a crack in process of development. Examination with a pocket magnifier will show a fine, slightly wavy crack at the fillet on the lower section of the piece, which was the inner end of the journal. This crack has penetrated to a depth of three hundredths to five hundredths of an inch below the surface. It is a progressive fracture in

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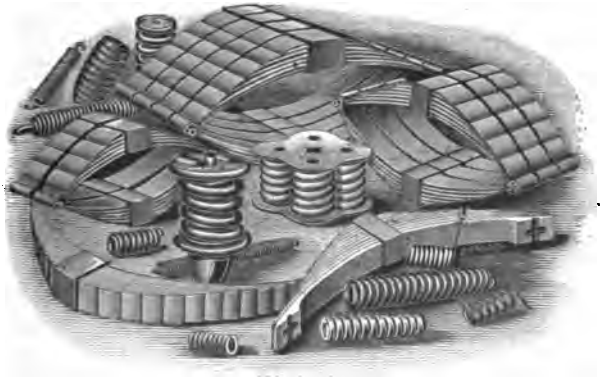

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its early stages of development. Inasmuch as this type of fracture frequently reaches a considerable depth before the journal finally breaks off, it is taken to signify that occasional stresses of exceptional severity are received, much above the usual load on the journal. If the magnitude of the stress was constant and maintained at its maximum value, a few hundred rotations of the axle, after a crack had begun to develop, would terminate in the complete destruction of the journal.

This approach to the limit of endurance of the axle is not characterized by any change in its outward appearance, nor by any change in the structure of the metal which has been detected, by means of which impending rupture may be recognized. Such knowledge depends upon previously obtained data concerning the tensile properties of the metal and experimental research upon the effect of repeated stresses similar to those which are received in service. An examination of the micro-structure of the metal of this axle showed a well-defined cellular network, across which the crack traversed. The direction of its course and position with reference to the meshes was apparently uninfluenced by the micro-structure.

The micro-structure of other material has also been examined after long continued stresses, which had ended in the complete rupture of the metal.

No change in the micro-structure was detected in that part of a steel shaft which had endured 150,000,000 repetitions of load under the maximum stress, which had ruptured the shaft, and other portions near the neutral axis, where practically no straining of the metal had occurred. These remarks refer to the results of repeated stresses in the vicinity of the elastic limit of the steel, which have been found competent to cause rupture without appreciable elongation of the metal. Axle fractures generally belong to this class, in which rupture is accomplished in all grades of metal, irrespective of their primitive toughness, with little or no elongation. It seems paradoxical that the ability of the metal to stretch may be destroyed without calling that property into action. Such, however, is the result of repeated alternate stresses which approach in magnitude the elastic limit of the metal. Lowering the stress prolongs the life of the material, and it seems reasonable to suppose

that certain loads might be repeated indefinitely without causing rupture. If, on the other hand, the metal is overstrained by a load which causes permanent set, the place of ultimate rupture may be localized. This is seen in the fractures of coupling links.

Before speaking of coupling links, I will exhibit this piece of journal, and by means of a magnifying glass the fracture can be seen. It is a little uncertain in some lights, but a fracture is there. It is at the end of the journal, not in the fillet, but at the commencement of same.

A new coupling link, like any link of a chain, is most likely to fracture at or in the vicinity of the weld. If the weld is a good one the link may stretch quite sensibly before breaking.

The short brittle fractures so often shown in coupling links, after having been for a time in service, are in consequence of the overloading and repeated distortion in shape, the local upsetting and indenting, to which they have been exposed.

When service conditions are such that permanent sets occur, early rupture may be looked for. It is hardly necessary to remark that such evidence of overloading should be guarded against in all important parts of a structure.

This remark is intended to be a very broad one. You can hardly take up a piece of metal that has been in some classes of service, without seeing marks upon it where it has been indented, bruised, hammered, or bent. That is starting it on the road to rupture at a lively pace. Where metal is intended to form a part of a permanent structure, such evidence should never be present. There should not be upsetting around rivet holes, whether the holes are punched or drilled. Punching is, of course, attended with loss in ductility, but a drilled hole may become brittle by upsetting, and it is a very common occurrence, as we all know, to find bolt holes in the webs of rails more or less upset. That destroys the toughness in that vicinity.

The fracture of a number of the suspender rods of the Brooklyn Bridge in July, 1901, furnished examples of fractures by repeated alternate stresses.

Here is a section of one of the rods. It has a number of cracks at the roots of the threads. Chisel marks represent the

position of the rod in the bridge. That is, the diameter parallel to the length of the bridge is indicated by the cuts on the opposite sides of the threaded portion of the rod. It would seem that fractures were started and had penetrated to quite a depth in this and in a number of other rods, in addition to those which failed completely at the time they were discovered.

Since the principal cracks are at the extremities of the diameter which was parallel to the length of the bridge, it is apparent that thermal changes, alternately expanding and contracting the trussed girders, were chiefly responsible for these cracks and completely destroyed a number of the rods.

If the principal cracks were in the sides of the rods transverse to the bridge, the explanation might be wind strains causing vibrations in that direction; but since those were in the direction of the length of the bridge, it seems fair to attribute the presence of cracks to thermal changes.

The direct tensile stress on these rods was said to be only 11 tons. The lowest tensile strength found in any of the old rods containing incipient cracks was 248,000 pounds, or more than ten times the direct load on them in the bridge. They were replaced by somewhat larger ones, the strongest of which displayed a tensile strength of 443,000 pounds, or more than twenty times the direct load placed upon it in the bridge. Eleven tons (22,000 pounds) against new material with a strength of 443,000! These figures would indicate that the indirect and perhaps unlooked-for stresses in the bridge exceeded in severity the direct loads provided for in the design of the structure.

I will come to a case nearer home, but an earlier one. Referring to the Bussey Bridge disaster of 1887, it is thought that an important feature connected with the design of that bridge has been generally overlooked. It will be recalled that the cause of the disaster was traced to the failure of certain loop welded hangers used in one of the trusses, and attention at the time centred on the unfavorable manner in which the loads were carried, by reason of the eccentricity of the loops, and was regarded as the peculiar defect of the design, which immediately led to the failure of the bridge. The manner of failure of the hangers suggests that another element of weak-

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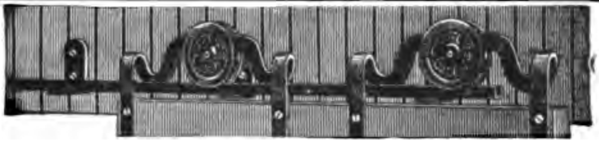

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ness was also present, namely, a tendency of the loops, which were very short, to split apart at the weld. The loops were apparently formed in the usual manner by bending the iron to the curvature of the pin, scarfing the end and welding it to the shank.

In cases were the loops are short and the diameters of the pins large, fractures — when loops are tested to destruction — commonly occur by splitting apart at the weld, the fracture starting at the sharp re-entering angle near the pin and extending backward to the end of the scarf.

Soon after the disaster three hangers were tested,— an old one from the wrecked bridge and two new welded ones. Drawings of two others from the bridge are shown in the Railroad Commissioners' Special Report on the disaster.

Out of these five fractured hangers, four failed in the manner just described. One of those in the bridge fractured in the shank above the loop in a manner consistent with the overstraining of the metal by reason of eccentric loading. The warning lesson of this disaster is not considered complete unless the defective proportions of the hangers are taken into consideration as well as their defective shapes.

A few remarks on the subject of boiler plates and riveted joints. Tests usually show the metal offered for boiler plates to possess the property of toughness in a marked degree. Such is its behavior in the testing machine. Instances of fractures in service, on the other hand, are very apt to show brittleness.

So frequently is this the result of severe local strains that an examination of the adjacent metal fails to show the presence of abnormal qualities, such as the evidence of the service fractures would suggest. Brittleness in locomotive fire-box sheets has been followed by tests of surrounding metal in which average elongation was displayed, and good bending tests even made upon strips containing the original brittle fracture. Such instances emphasize the need of inquiring into the magnitude of the service strains and the frequency of their occurrence, so far as this may be done.

Certain information may be obtained upon boilers when the usual hydrostatic test is applied. These photographs show a

measuring instrument in position for observing some of the changes in dimensions of a boiler when subjected to the hydrostatic test. Observations were made on the contraction in length of the shell when interior pressure was applied, an effect which accompanies the diametrical expansion. The tubes, being under exterior pressure, are extended in length. The longitudinal movement of the shell being in one direction, and the movement of the tubes in the other, results in bending the metal of the heads at the flanges very noticeably, particularly so where the tubes are located in close proximity to the shell sheets.

Measurements have been taken across the manhole and on the shell on each side of this opening. The results showed that the reinforcement of the manhole frame was insufficient to compensate for the loss in strength due to cutting away so much of the shell sheet. The strains in the shell, greatest in the vicinity of the manhole, gradually diminished in passing along the length of the boiler.

Measurements of this kind show how unequally the different parts of the boiler are strained under hydrostatic pressure in a cold state. It can be easily understood how local strains of greater severity may exist in the metal when the boiler is exposed to working conditions of temperature and pressure.

In this photograph a measuring instrument is shown on the shell sheet on the top of the boiler placed in a longitudinal direction. The next photograph shows the measuring instrument spanning the manhole opening.

A number of specimens will be exhibited and described. In soft steel a centre punch mark may elongate in diameter 200 to 300 per cent. without localizing fractures. Here is a sample of mild steel. A centre punch mark was made, defining an inch section which occurred very near the point of rupture, but the influence of the centre punch was not felt on that grade of steel. As may be seen, the fracture occurred 3-16 of an inch away from the punch mark. Hard steel is affected by slight causes. A centre punch mark will frequently locate the place of rupture in this grade of metal. Steel hardened by punching, shearing or cold distortion in general has similar traits to steel which is hardened by chemical composition. It may frac-

ture in a brittle manner. This is a harder piece of steel, and the centre punch mark was made to define the inch sections on this as on the more ductile steel. The presence of the centre punch mark, which is not very deeply made, was adequate, however, to locate rupture. In this sample there is a radiant appearance at the fractured surface, with its centre at the punch mark which indicates where the fracture began.

A punched hole may cause disaster. Here is a steel angle bar. This piece of steel represents a member in a roof truss which fell in this city and caused loss of life. The presence of a punched hole so reduced the strength that fracture occurred under a load of tension in the testing machine before the elastic limit of the full section was reached. It failed when the elastic extension was less than one thousandth and a half of its length. This must be regarded as a hazardous use of material. The metal in the vicinity of the punched hole is granular. It is silky at a distance from there. Inasmuch as rupture took place before reaching the elastic limit of the angle as a whole, such roof trusses, and other important members, if they have punched holes, may be dangerously weak.

The appearance of fractures in the sheets of a fallen water-tower called forth a remark characterizing the metal as brittle as glass. The metal was, in fact, a tough one. The brittleness in the tower was the result of punched holes and sheared edges. Subsequent tests showed good ductility in the steel beyond the affected zones.

These examples show how fractures may have an unfavorable appearance, due to the treatment of the steel in punching or in its subsequent use by overstraining, and tend to cause reproach to fall upon the metal which if properly placed would apply to the manner in which it has been used.

While the testing machine is recognized as the chief source of information on the strength of materials, still in the application of this information the conditions under which those physical properties were developed must be kept in mind. The weaker grades of steel may, with proper use, afford strength and safety; the strongest steels admit of destruction.

Mysterious fractures are not common. Incomplete knowledge of the strains in service accounts for many unexpected

fractures. If steel fails in service it has been overworked. Evidence of overwork, local or general, is shown in the permanent distortion of the material. In a large number of instances the causes which promoted rupture are indicated by the appearance of the material.

These remarks refer to types of fractures in which the overloading has been excessive. So conspicuous are the indications that this class of fractures are of comparatively easy avoidance, if the warnings are heeded. It is thought that the larger number of failures in service are comprised in this class.

In another class of fractures, the result of repeated stresses just within the danger zone, no evidence is presented of impending rupture, or at least none has been detected. Here the limit of endurance is judged of through comparisons of the stresses in service with direct experimental data obtained under analagous conditions of loading.

In conclusion it may be remarked that a careful determination of the stresses in service, both local and general, is regarded as essential for the proper use of those physical constants which are obtained by means of the testing machine.

THE PRESIDENT: Gentlemen, we have all heard the very interesting remarks of Mr. Howard, and many of us have seen the samples that he has so kindly shown to us. Now it is up to us to have a little something to say on the subject. I would be very glad for any or all of the members to participate in the discussion, asking Mr. Howard any questions that may occur to them, and I think he will be very glad to answer them, at least I will say he will. I don't know whether he will or not, we will assume that he will.

MR. HOWARD: If he can.

THE PRESIDENT: You know I don't like to call any gentleman's name. Professor Lanza, I think you could start us off on this just as well as anybody. Professor Lanza, gentlemen.

PROF. LANZA: Mr. President, I have been very much interested in the remarks of Mr. Howard, and I think it has been exceedingly profitable for us to hear the matter of the strength of materials, and especially the strength of metals, discussed.

In former times there was a strong tendency to buy material and use it without testing, and while it is a fact that in certain quarters such tendency exists today, nevertheless there is now much more reliance on the testing machine, and much more importance is attached to seeing that specifications for material are made and fulfilled.

One thing that seems to me of particular interest in Mr. Howard's talk is the importance that he has laid upon the question of alternate stresses. This question, though it has received the attention of a number of people, is almost in its infancy, but it is forcing itself to the front, especially among railroad men, who are beginning to realize its importance. For my part, I have not the slightest doubt that before very many years requirements intended to insure the power of resisting alternate stresses will occur in our specifications, and will have to be met by the manufacturers of iron and steel. Such requirements will be especially needed in the case of materials employed on railroads. Thus alternate stresses occur in many parts of the locomotive, as in the rods, the axles, the draw-bars, the pins, etc.

Moreover, it is well-known today that the requirements for metal which is to be subjected to alternate stress are different from those needed in other cases. Mr. Howard has made a very long and careful investigation of this subject, and has been kind enough to give us a great deal of information tonight in that regard.

MR. BAKER: Mr. President, I would like to ask a question of Mr. Howard regarding repeated stresses or, I would say, vibrations. Take, for instance, a horizontal brake rod, 3-4 inches diameter, that is not subjected to sufficient load to strain it to anywhere reach its maximum limit, that is, simply lying or sliding on a block of wood. In time, if made of Norway iron, it will break off like a pipe stem, become crystallized, as it were. Now, isn't that caused by a vibration instead of a repeated stress?

MR. HOWARD: Well, vibration I should class as repeated stress, as a question of definition. But perhaps some tests which we have now in progress may have a bearing on your question. We have recently taken some steels — some of which were quite soft, none so soft as Norway iron — and sub-

jected them to repeated stress of high limit. In figures the stress we used was 60,000 pounds to the square inch. That would cause a permanent elongation, but under conditions of bending only outside portions are most severely strained, and the metal under that high fibre stress ruptured at about, say, 6,000 repetitions. We took the same grade of steel, reduced the fibre stress to 50,000 pounds per square inch; then the number of repetitions was about 17,000. Reducing the fibre stress on the next bar to 45,000 to the square inch, the number of repetitions was above 70,000. Then dropping to 40,000, there were several hundred thousand repetitions before rupture. The last bar of the series, at 30,000, is now running, and has made about 10,000,000 repetitions at the present time.

Vibratory stresses must be looked upon in the light of how much they are equivalent to in pounds per square inch. Piano wire will endure a high fibre stress for a great many years, and it is the function of a piano wire to vibrate; but in the amplitude of vibrations the change in fibre stress is not very great, and so some of the wires in the upper octaves stand under stresses considerably higher than 100,000 pounds, I should say some were 140,000 to 150,000 pounds to the square inch.

But, coming to your case of Norway iron, which is a particularly soft iron, and impresses us with great favor to see it bend. That, however, is about all that we can say about it that impresses us favorably. It will take a permanent set very easily, and after you have bent it backward and forward a few times its toughness is gone. You cannot exhaust the toughness by stretching, and then doing it over again. If the stresses are of comparatively small magnitude we will reach the limit of rupture without display of ductility. This is not explainable at present, but the result of experience shows that all grades of steel, no matter how tough they are in their primitive state, may be ruptured by repeated stresses or vibrations, which are the same thing, without the display of ductility, and the soft steels will reach rupture under a lower stress and sooner than will a high steel.

Going back to the series of tests that I mentioned, which started with 60,000 pounds and worked downward, we have also a series of several different carbons, increasing in hardness and

in strength, and the fibre stress which ruptures the lower one with a few thousand repetitions does not rupture the higher steel; it has simply a greater elastic range. And I might say in regard to a series of muck-bar axles — I know this is getting on to polemical points, that some have a great fondness for muck-bar axles, but certainly an axle with an elastic limit of 18,000 pounds, which we find in some muck-bar axles, can endure a repeated stress of 20,000 pounds but a few times, whereas a steel axle having an elastic limit about as high as the tensile strength of the muck-bar metal would endure 20,000 repetitions millions of times, without rupture. Both can be made to break finally without any display of ductility. The difference is this, the harder steel, having a higher elastic limit, a higher range of elastic movement, can endure a higher working stress than the lower one.

PROFESSOR LANZA: Mr. President, I should like to ask Mr. Howard what was the tensile strength and what was the limit of elasticity of those particular bars of which he spoke first.

MR. HOWARD: The elastic limit was below the maximum of the highest stresses in some of the bars,— it was between the highest of our fibre stress and the lowest.

PROFESSOR LANZA: I mean what grade of steel was it, what was its tensile strength, and what was its limit of elasticity?

MR. HOWARD: In those several steels the elastic limits range from 48,000 to 83,000, and the tensile strength from about 70,000 to 150,000.

THE PRESIDENT: I should like to hear from some other gentleman.

MR. HOWARD: Professor Lanza, in regard to the elastic limit and the fibre stresses which we have employed in some cases, we had one bar of abnormally high tensile properties. It had an elastic limit of 117,000 pounds and a tensile strength of 150,000. That metal was ruptured under repeated stresses of 40,000 pounds, the total range in tension and compression being materially below the elastic limit of the steel taken in one direction. Some plain bars which were subjected to endwise tension and compression steel bars illustrated a change in the physical properties which resulted from over-straining. There was a number of steel bars with an elastic limit of

about 50,000 pounds. The elastic limits were the same, substantially, in tension as in compression; that is, if we applied a stress of 50,000 pounds, the bar would stretch and recover; reversing the load and applying 50,000 pounds compression, it would shorten in length and recover. Here was a range of 100,000 pounds taken both ways, which could be endured without permanent set Upon overloading that steel in tension 1,000 pounds, or applying 51,000 pounds per square inch, the immediate effect was to nearly destroy the compressive elastic limit. It was not 49,000, adding up to 100,000 as before, the tensile elastic limit having been raised by the overstraining to 51,000. The compressive elastic limit, on the contrary, was about 20,000 to 25,000, and probably sets occurred earlier than we detected them. From this it may be said that overloading in one direction materially detracts from the elastic limit in the opposite direction; and, if there are local overstrains in bars subjected to repeated stresses, certain phases of weakness are introduced, as shown by the lowering of the elastic strength in the direction opposite to the overstraining force. This behavior aids us a little in understanding why there is a difference between alternate stresses and direct ones.

THE PRESIDENT: Are you all fixed up, Mr. Baker?

MR. BAKER: No, not quite.

THE PRESIDENT: Stand up, then, and say your little bit here. Perhaps Mr. Howard did not quite understand what you were driving at.

MR. BAKER: I want to go back to that brake rod that I was speaking of. One I have particularly in mind is a brake rod of about 300 pounds maximum pull and five-eighths or three-quarters of an inch in diameter. Made of Norway iron or low steel, we find the life of those rods is five or six years, as near as I can find out. That is, we have had quite a number break. For that purpose we use a good fibrous iron, or try to get it as near as we can; it gives better results, although our blacksmiths do not like to work the fibrous iron that we buy, and the iron makers do not like to make the iron that we specify. In fact, we cannot get it. Talk about our specifications that Professor

Lanza spoke of! we practically have to take what they furnish, or let it alone.

MR. HOWARD: I understand the fibrous iron behaves better, has greater endurance, than the Norway.

MR. BAKER: Yes, sir, that has been our experience.

MR. HOWARD: Probably it is stronger, has a higher elastic limit.

MR. BAKER: I should think so.

MR. HOWARD: Where does the fracture of these rods occur?

MR. BAKER: Right in the middle of a bar, or wherever it lies over a guide or anything of that kind — a little block of wood, for instance — it will break off just like a pipe stem.

THE PRESIDENT: What Mr. Baker is driving at — excuse me — is this: He wants to know why, resting on that block of wood, it should break right there.

MR. BAKER: That was one. That was what I asked about, the vibration and the fibre stress, because our load is comparatively light for the size of the rod and its strength. But where it lies on a block of wood is where it breaks invariably. It is a little hammer or a jar going on day by day that crystallizes it, so to speak.

MR. HOWARD: I should say off hand, that the stress on your rod is higher than you expect it is. Here was a case that I instanced, in the Brooklyn Bridge, where the engineers provided a rod having a tensile strength of 248,000 pounds to sustain a load of 22,000. They put in one of 443,000 pounds to replace one of 248,000, and still to carry a load of only 22,000 pounds. They are either having stresses very much beyond what they are providing for, or else they are not providing material in the right place and in the right direction. If you have a rod of comparatively low tensile strength, loaded with a few pounds only, you can rest assured that the conditions of service are such that that material is strained very much higher than the direct pull on the rod indicates. The whipping back and forth is probably sufficient to apply a transverse stress, and stresses magnify very fast in that way. We can bend a bar of considerable size, reverse the bend a few times and break it, which would require many thousand pounds direct pull to fracture. I feel quite confident that there is some whip-

ping motion which increases the stress, and the rod might very well break where it passes over a block of wood. The block might introduce an intense bending moment at that place, and rupture would be located there in consequence of repeated bends. The direct pull on the rod might not be much of a factor in the case.

MR. BAKER: In this case I don't think it was direct pull; I think it was vibration. We have Mr. Doty of the Elevated Railroad here, and he can tell us of some of the breaks in our trucks, where there is practically no strain excepting a vibration or jar, but where an inch or an inch and an eighth bolts broke off the same way. Some of them, I believe, are case hardened.

MR. HOWARD: That might help things along somewhat, because with the case hardening you have a very brittle exterior, and a very slight defect there, as on one of those brittle steels exhibited tonight, would start a fracture which would continue through the rest of the metal without hesitation.

MR. BAKER: It would not necessarily imply that that would be the result of case hardening, would it? You increase your tensile strength, don't you, if you harden it, if you temper it?

MR. HOWARD: A case hardened bar and a Harveyized bar are very much the same. If you start with a low carbon steel, of .15 to .20 carbon, and case harden it or Harveyize it, you may have one per cent. of carbon in the exterior layer. The exterior taken alone might have high tensile strength, but it is very brittle, and a very slight surface defect — scratch — would cause a rupture. After the rupture has passed through the hard exterior it will go through the soft core without any display of ductility. Metal case hardened is well adapted to resist wear, but I would hardly recommend it for strength. The combination of hard and soft metal is not quite satisfactory from all points of view.

THE PRESIDENT: Any other gentleman?

MR. RILEY: Mr. Chairman, I would like to ask Mr. Howard if he can give us any information as to what he considers the best method for testing steel such as is used in steel boilers.

THE PRESIDENT: I might say, Mr. Howard, that Mr. Riley is a locomotive engineer, and perhaps these high pressures

worry him every once in a while. You can talk to him as a locomotive engineer. There are three or four more right down there, and whatever you say to them will do them all good.

MR. RILEY: Not exactly, Mr. President. We are getting into the era of high pressure and also superheated steam. I see where they have been using boilers on the Prussian State Railroad, and they have been testing them to 300 pounds to the square inch. The question I was getting at was, the best method of testing steel for the use of locomotive boilers.

MR. HOWARD: My train of thought this evening has been in the line of direct observation on the material in service. We can test material,—tell you the physical properties, what it ought to be if good steel, that it should have a certain elastic limit, a certain tensile strength, elongation and contraction of area. That is desirable information to start with. But the lesson that I desire to call your attention to is, the desirability of finding out what the material is doing in service. We have made a few tests on boilers and showed that the strains were intense at certain sections. Under pressure the shell contracts and the tubes extend longitudinally, and thus bend the metal of the heads at the flanges. It is by concurrence of opinion thought necessary to have a tough steel, and I believe that is essential for boiler-plate purposes, but you must go a step beyond and ascertain what the material is actually doing in the boiler. We can make tests and show that soft steel will not endure a very high stress under repeated bending without rupture, but we cannot tell what the stress is in the boiler. We can compute the stresses with a certain degree of approximation, but may leave out factors which have a very important bearing. We must attach special value to information which comes from direct observation on the boiler itself. If the metal where a manhole is cut away stretches more than the surrounding parts, we know that that is a weak point and must strengthen it. I would like to answer your question as definitely as I can, but, having good physical properties, say 30,000 to 35,000 elastic limit, and 55 000 tensile strength, with an elongation of 20 per cent. before rupture, a contraction of 40 per cent., which are good qualities

for boiler steel, this only means that you have got good steel at the start. Having obtained it, you must look in detail carefully to the boilers and see that you do not overstrain them locally. That is the real feature to be considered.

THE PRESIDENT: If Mr. Howard had had as much experience with locomotive boilers as a good many of the men in this room, in his talk to Mr. Riley I think he would have said that they don't know all the stresses, and that it would be a very good idea for these engineers to take as good care of their boilers as they can, so that exceptional stresses should not occur. Excuse me for knocking, Mr. Riley. (Laughter.) Would any other gentleman like to say something on this subject?

MR. BIGELOW: I would like to ask Mr. Howard in regard to the desirability of using old rails in structural work. I judge from what he said that it may not be the safest thing to do, and I would like to bring it out a little more clearly. For example, the use of rails for floor beams in forming a floor in connection with concrete, and particularly if the head of the rail was on the lower or tension side, if that would not be as well as having the head on the upper side. The idea being that on account of there being such an excess of metal in the head of a girder rail over the foot that it would seem as if, with the assistance that the concrete must give on the compressive strains in the upper part of the floor, that the floor would be stronger on the whole than in the other case, unless this loss of ductility and tensile strength as spoken of by Mr. Howard, more than makes up for this advantage.

MR. HOWARD: There is loss in strength, which must be borne in mind, and it would be prudent in using old rails to keep the heads in compression as far as possible. This loss of strength is considerable. But when you use old material in re-enforcing concrete, as I take it,—

MR. BIGELOW: Yes, or on the floor.

MR. HOWARD: The opportunities for knowing what the loads are there are very good. You know what the stress to be dealt with is, and I should not feel in doubt about the use of old rails for such a purpose. It is not so serious a matter as a case in the track, where the removal of one tie, or the failure to tamp another, will bring a severe stress on the rail. What

with the unbalanced parts of the drivers and other causes you can readily see that a high fibre stress will be occasionally received. The conditions of railway material are such that high stresses are now and then possible. They are not received generally. If it were so, we should not have any of these progressive fractures of journals before us. Before a train could move many miles rupture would be complete. But rounding curves, striking frogs and switch rails, lurching on uneven road-bed, all contribute towards an overstrain now and then. Some journals do not finally break off until half the section has been progressively ruptured. In the use of old material with concrete I do not think you have a wide range between maximum and minimum stresses, and should not feel any hesitancy to use the material under proper conditions.

THE PRESIDENT: Some other gentleman? Mr. Desoe.

MR. DESOE: My question will require but just a word for an answer. I would like to ask what has been found to be a safe maximum weight of a wheel to a rail without causing the fibre to be crushed. I refer particularly to a driving wheel of a locomotive.

MR. HOWARD: You are raising a question difficult to answer. The controlling conditions there might be summed up in this wise. It will depend on the diameter of the wheel in part, and in part on the curvature of the head of the rail. Whether the contact is at a point or on a line the conditions will be modified. The question can hardly be answered off hand. We had a case of this kind, which illustrates the action of a roller on a plane surface. There was a roller of large radius of curvature—114 inches. On a flat platen with roller of that radius and a length of twelve inches we could apply 800,000 pounds without appreciable set to the roller or the surface on which it rested. The question involves a consideration of material subjected to cubic compression. If material is compressed in all directions, so far as I have been able to ascertain no effect is produced, no detrimental effect results. But if one particle is moved a greater distance than its elastic limit from the adjacent one a permanent effect results, and it does not matter what the stress is. With a wheel of very large radius of curvature, while the stress might be very great, the distortion is so easy from one

part to another that no two adjacent particles are strained beyond their elastic limits, so that if the wheel has a radius of curvature large enough and a sufficiently wide tread, I can hardly imagine a force that would not be successfully resisted. It would then be practically a case of cubic compression. We have put soft steel of 30,000 elastic limit under pressure of 117,000 pounds in a hydrostatic press, and it did not disturb the properties of the metal. It had the original properties unimpaired. The subject of wheel pressure is involved in the question of cubic compressibility.

MR. C. B. SMITH: I would like to ask, for our records, if Mr. Howard has any doubt as to the wisdom of using forged steel instead of forged iron in such places as locomotive axles, crank pins, and piston rods.

MR. HOWARD: No, I have not. I should prefer a strong, medium tough steel to a very tough low strength iron. Both will rupture in a brittle manner, but it will take a higher stress to rupture the steel, and a longer time to do it, ordinarily, than would be the case with a puddled iron, soft and low in elastic limit and strength.

MR. C. B. SMITH: Cannot smaller dimensions be used for the steel than for any grade of iron that you know of?

MR. HOWARD: It necessarily follows that if one is stronger than the other it would sustain a higher fibre stress, and that would mean, to sustain a given gross load, lower sectional area. That necessarily follows.

THE PRESIDENT: Does any other locomotive man want to ask a question?

MR. MANNING: I would like to ask Mr. Howard if he has made any experiments which conclusively show that iron or steel subjected to stresses or vibrations well within their strength, within perfect safety, deteriorate in strength or become more brittle. I refer now to material which has not been strained at all.

MR. HOWARD: Metal that is merely laid away to rest?

MR. MANNING: No, material which is in use, but within its strength, not overstrained.

MR. HOWARD: I think there is a limit below which repeated loadings will not have an injurious effect, that we can not say

that any load, however small, will ultimately rupture material.

MR. MANNING: It does not deteriorate in strength with ordinary safe wear? That is the point.

MR. HOWARD: No. The indications are that every piece of metal has a certain safe limiting stress. I won't undertake to say what the limit is between safety and unsafety, but believe there is a limit within which it could be worked indefinitely without deterioration.

THE PRESIDENT: Any other gentleman? I should like to have somebody get up and tell us something, instead of asking questions.

MR. MILLER: Mr. President, I was quite interested in Mr. Baker's remarks, and this gentleman on my left here seems to bear on the same point, regarding the matter of vibration. I call to mind a case in which the diameter of a rod was given to be three quarters of an inch by one of the most reliable concerns in this country. It stood well under a car of 60,000 pounds in weight. But in the same position that rod was used under another car, where the vibration was much greater and the weight of the car was 40,000 pounds, and it would not stand. This is conclusive proof to me that the vibration, regardless of the load, has a great deal to do with the breaking of the metal.

Before I sit down, Mr. President, I should like to say that I looked with much interest at some samples of iron that the Professor handed around, and I want to show him one sample. It was something that caused me a good deal of worry the other day, and at that time I wished it was where it would never be seen. (Showing sample to Mr. Howard.)

THE PRESIDENT: While Mr. Howard is looking at that I will call on Mr. Webster.

MR. WEBSTER: Mr. President, This should be of some value to Mr. Smith, as he spoke about piston rods, etc. I have in mind an experience where on a large mill engine they used three different kinds of materials for piston rods,— the first was a high-grade high-tensile-strength steel; the second was a low-carbon open-hearth steel; and the third was ordinary hammered iron. In all three cases they gave out at the same place. The duration of time between their giving out varied

very little. They gave out in the key-way, where the piston rod fitted into the crosshead. It was a taper fit and the key was driven in, holding the piston rod into the crosshead. It is possible that, having used these three different materials, such uses may be of value in determining which one was the best for the purpose, although I am free to confess that I do not know myself, as their life was so near as to be the same.

THE PRESIDENT: Do you remember the duration of service? That would be for Mr. Smith's benefit also.

MR. WEBSTER: The steels went a couple of years longer than the iron did, and the two steels — two different qualities of steel — were about the same duration of time.

THE PRESIDENT: The iron stood much less time?

MR. WEBSTER: Stood much less time, — about six years in the case of the steels and about four years in the case of the iron. We eventually had to ream the crossheads out and thread them and put in a threaded piston rod at the crossheads to overcome the difficulty.

MR. HOWARD: The opportunities in practice are not always rable for ascertaining what the service fibre stresses are. We do not have, perhaps, so many perplexing things in a testing laboratory as are met in service. We endeavor to begin experimental research under known conditions, and then are enabled to follow the results and determine what the natural laws are; whereas in service I am free to admit that you must be embarrassed by the difficulties of learning what the stresses are. Shafting frequently breaks. We do not know what the pull on the belt has been, nor whether the boxes have been in alignment, and hence cannot say what the stresses were. In our experimental research we apply a definite load and watch the effect. Then we are enabled to say what metal will best endure a given load.

This bolt (referring to that handed him by Mr. Miller) does not present anything very unusual about it.

A MEMBER: That is the fault of the purchasing agent.

MR. HOWARD: I have seen bolts like that before.

MR. MILLER: Did you ever see any worse-looking ones?

MR. HOWARD: Yes, I have seen them worse and better; this is an average one.

MR. BAKER: Mr. President, on the question of vibration I would like to hear a little more. We have had a little something in that line on account of polygonal wheels on our elevated road. We have got one of our shop foremen here, and I would like to have him get up and tell us something about that. We have had lots of bolts and one thing and another break. Since we are grinding our wheels more often to prevent the noise, may be it is getting better. And he can tell us what metal is giving the best results. Mr. Doty is here.

The PRESIDENT: Mr. Doty, we should be pleased to hear from you.

MR. DOTY: I do not know as I can say much. We have had trouble due to crystallization. Our brake rods, running from brake cylinder to truck, have a turnbuckle in them for adjustment, and to take the strain off the thread we have a 1 inch piece of ash 4 inches x 8 inches under the rod, to carry the weight. Just as the rod leaves the block is where they break, showing crystallization, but two inches or three inches away it shows little or no crystallization. We have had truck and motor bolts show crystallization.

MR. HOWARD: I should like to suggest a possible remedy, if I understand the case. As I understand it, the brake rods fracture over this piece of wood. I should put in some more pieces of wood and further restrict transverse movements by additional points of support.

THE PRESIDENT: Perhaps there is no opportunity for any more wood there.

MR. DOTY: We had a pedestal bolt break last week. This is a tie bolt under the journal box.

MR. HOWARD: What is the shape of that rod?

MR. DOTY: It was tested at the Arsenal, I think. It is a flat rod, about 2 inches by an inch or an inch and a quarter, turned down on one end for 1 inch thread.

MR. HOWARD: The metal had good physical properties, but the rupture belonged to the class due to repeated bending. I did not know what position the material occupied in the truck.

MR. DOTY: The truck has inside hung brakes, and every time the brakes are set, of course there would be a tendency

to force the wheels away from each other, bringing a heavy strain on this bolt.

MR. HOWARD: Yes, it would appear so.

MR. DOTY: That piece has been in service about nine or ten months.

THE PRESIDENT: Any other gentleman? It is getting late now, and we would like to have you speak right up quickly. The opportunity for speaking here is limited now, so you must step up. I would ask Mr. Howard if he has any remarks to make in closing.

MR. BIGELOW: I should like to move that the Club offer a vote of thanks to Mr. Howard for the very instructive address that he has given us this evening. I am sure I have enjoyed it very much, and I think the rest have.

(The motion was seconded.)

THE PRESIDENT: As soon as I close the subject I will put that motion, if you please. No other remarks being heard, the subject is closed.

It has been moved and seconded that a vote of thanks be extended to Mr. Howard for his very interesting remarks here tonight.

(The motion was adopted unanimously).

MR. BAKER: I move that we adjourn.

THE PRESIDENT: Excuse me, Mr. Baker, just a minute. There are one or two announcements.

The subject of the May meeting is to be "Boiler Design," by Mr. F. J. Cole, Mechanical Engineer of the American Locomotive Company.

I would incidentally announce that the New England Street Railway Club is to have a Ladies' Night this week, Thursday, in this hall.

(Meeting adjourned.)

W. D. DRAKE,

CLEVELAND,

DIED APRIL 22, 1903.

New England Railroad Club

May 10, 1904.

SUBJECTS FOR DISCUSSION:

BOILER DESIGN.

Paper by Mr. F. J. COLE.

PASSENGER CAR INTERCHANGE.

Paper by Mr. F. A. CARR.

E. L. JANES, SECRETARY, SOUTH TERMINAL STATION, BOSTON, MASS.

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CHARLES F. BAKER, President	" 1902,	" 1903.
F W. DEAN, President	" 1903,	" 1904.

The regular meetings of this Club are held at Pierce Hall, Copley Square, corner of Dartmouth Street and Huntington Avenue, Boston, on second Tuesday of each month, excepting June, July, August and September.

NEW ENGLAND RAILROAD CLUB

Published Monthly, except June, July, August and September,
by the New England Railroad Club.

E. L. JANES, SECRETARY, SOUTH TERMINAL STATION, BOSTON, MASS.

$1.00 A YEAR. *Boston, May 10, 1904.* 15C. A COPY

A REGULAR MEETING of the New England Railroad Club was held at Pierce Hall, Copley Square, Boston, on Tuesday evening, May 10, 1904, at 8 P. M., President W. B. Leach in the chair.

The following members registered:—

Adams, W. H.	Craig, Jas.	Harmon, B. F.
Adams, T. W.	Craig, Andrew	Hartwell, H. B.
Allen, C. Frank	Deane, J. M.	Heath, Elroy N.
Armstrong, C. R.	Desoe, A. J.	Hegeman, B. A., Jr.
Averill, A. B.	Desoe, C.	Higgins, G. W.
Bailey, Charles A.	Doherty, Edw. J.	Hindle, Wm.
Baker, C. F.	Durkee, H. B.	Hudson, B. F.
Bean, W. F.	Eddy, F. H.	Humphreys, James.
Bodwell, G. Arthur	Eldridge, A. H.	Hundy, A. W.
Butterfield, W. R.	Ewart, John	Jewett, H. F.
Byron, J. E.	Field, Wm. W.	Kanaly, M. E.
Cahan, F. D.	Fitz Gerald, J. M	Keay, H. O.
Cain, P. E.	Ford, J. M.	Leach, W. B.
Carr, F. A.	Flannery, John J.	Lindley, R. M.
Chain, E. E.	Fries, A. J	Lord, G. W.
Chamberlain, J. W.	Gehman, G. W.	Lovett, Chas. C.
Chamberlain, J. T.	Gilman, John H.	Lynch, Henry H.
Cleaves, F. C.	Goodwin, C. E.	Manning, J. P.
Copp, Chas. E.	Greenwood, H. A.	Marden, J. W.
Cowden, Thomas	Gunnison, F. A.	McCombs, Henry W.

MacEnulty, J. F.
Maycock, J
Miller, E. T.
Moore, Chas. L.
Moran, Andrew
Morrison, F. A.
Norton, A. O.
Olson, G. A.
Park, W. R.
Patterson, S. F.
Pickford, Samuel
Post, C. J.
Potter, E. E.
Rice, Edmund
Richardson, A. H.
Richardson, H.
Rhine, A K.
Robertson, W. J.
Sherburne, Chas W.
Sheffield, A. C.
Spencer, J. H. C.
Smith, W. C.
Smith, W. B.
Smith, C. B.
Smith, P. C.
Stiles, A. L.
Swett, G. B.
Swett, G. W.
Sutton, G.
Thayer, Albert
Tilton, F. A.
Towle, J. M.
Tuttle, T. Edward
Webster, George S.
Wesdell, Frank F.
Westcott, S. S.
Wetherbee, F.
Wheeler, R. B
Whitham, J. G.
White, A. M.
Wood, Walter M.
Woodward, C. N.

The President: The first business of the meeting is the approval of the minutes of the previous meeting. I would say that the Proceedings have not yet been distributed, owing to the delay caused by the delay in printing the Proceedings of the March meeting, which has been caused by the necessity of having to secure a large number of plates, etc. The minutes are no doubt correct, and they will stand as they will appear in print. Are there any committees to report, Mr. Secretary?

The Secretary: None.

The President: Is there any Unfinished Business?

The Secretary: Nothing in the way of unfinished business.

The President: Does any member know of any unfinished business? If not, we will pass to the new business. Is there any New Business, Mr. Secretary?

The Secretary: New members.

The President: Will the Secretary read the names of the members who have been elected by the Executive Committee?

The Secretary: A. H. Eldridge, Superintending Engineer, North Packing and Provision Company, Somerville; John A. McRae, Chief Engineer, Quincy Market Cold Storage Company, Boston.

The President: The two gentlemen whose names have been read were elected members of this Club by the Executive

Committee this evening. Is there any other new business? I would say that under the head of "New Business," there is one little item that we will defer until the proper time, as the second paper of the evening will have a bearing on the subject, and it will be better understood and can be more clearly considered after that has been read. In connection with that the next order of business is "Appointment of Committees." That will lie over until a little later. If there is nothing further we will pass to the papers of the evening. The first paper was to be on Boiler Design. We expected to have with us Mr. F. J. Cole, the Mechanical Engineer of the American Locomotive Works at Schenectady, but unfortunately he is unable to be present. He has written the Secretary a letter, which is self-explanatory, and the Secretary will kindly read it.

MR. EDWARD L. JANES, Secretary, May 7, 1904.
New England Railroad Club,
Back Bay Post Office, Boston, Mass.

DEAR SIR: — Replying to yours of the 5th inst., and your kind invitation to meet the Executive and Finance Committee on Tuesday, May 10, has been received. I am very sorry, owing to previous engagements, that it will be impossible for me to be in Boston on that date, and regret very much that I will not have the pleasure of meeting you and the Railroad Club in Boston.

I enclose the paper on "Boiler Design," which I hope you will read. The subject matter follows strictly the six headings or sub-divisions as outlined in your original letter. I regret that the paper is in a more or less incomplete state, but hope it will bring forth an interesting discussion.

Yours very truly, F. J. COLE.

THE PRESIDENT: As Mr. Cole is not to be here and has sent his paper, we have asked one of our members, Mr. FitzGerald, of the Boston and Albany road, to read it, and he has kindly consented to do so. I would ask Mr. FitzGerald to step to the platform and favor us.

BOILER DESIGN.

By F. J. COLE.

Your Secretary has asked me to prepare a paper on the subject of boiler design, specifying at the same time six headings or sub-divisions of the subject. These are as follows:

1. To investigate the proper location water glasses and gauge cocks, in relation to crown sheet, and the center line of the boiler.
2. The proper slope of crown sheet expressed in inches per foot of length.

3. Is the automatic low water detector a desirable attachment for use on locomotives?
4. The destruction of side sheets in wide fireboxes, and reasons therefor.
5. The best form of radial stays.
6. The boiler tubes; with special reference to length, arrangement and spacing to improve the circulation and reduce the trouble from leaky flues.

I have endeavored to follow strictly the plan as outlined, writing out briefly, as they occurred to me, a few notes upon each division. I have not been able, owing to the requirements of business, to spend as much time in the preparation of this paper as the subject warranted, but hope that even if no new thoughts are presented, that the paper, although brief, may be the means of bringing out a full and vigorous discussion.

"To investigate the proper location of gauge cocks and water gauges, in relation to crown sheet, and center line of boiler."

These fittings are usually located on the backhead of boiler more for convenience than because of its being theoretically correct. Strictly speaking a uniform amount of water can be more easily maintained if the gauge cocks are located on a vertical line passing through near the center of gravity of the water. While this can be approximately done on the longitudinal center in case of Wooten boiler with the cab ahead of the firebox, it is manifestly impracticable to do this for the transverse center. The best that can be done in practice for this class of engines is to locate them on the side of the boiler and in a location which in a general way approximates the center of the boiler. The majority of boilers have these appliances located to suit the cab arrangements, within convenient distance of the engineer, the gauge cocks, therefore, being placed on the right hand side on or near the backhead and the water gauge on the right or left hand as suits best the location of other fittings.

There is an advantage in locating the water glass on the left hand side as with the gauge cocks on the right hand side the mean height of the water as shown on both sides will give the real height uninfluenced by the rolling of the engine. As a general proposition it seems best to locate these fittings in a convenient location so that they can be frequently tried or observed rather than to comply with theoretical considerations. With curved crown sheets and fireboxes of moderate width

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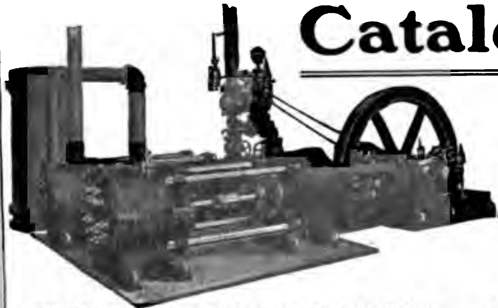

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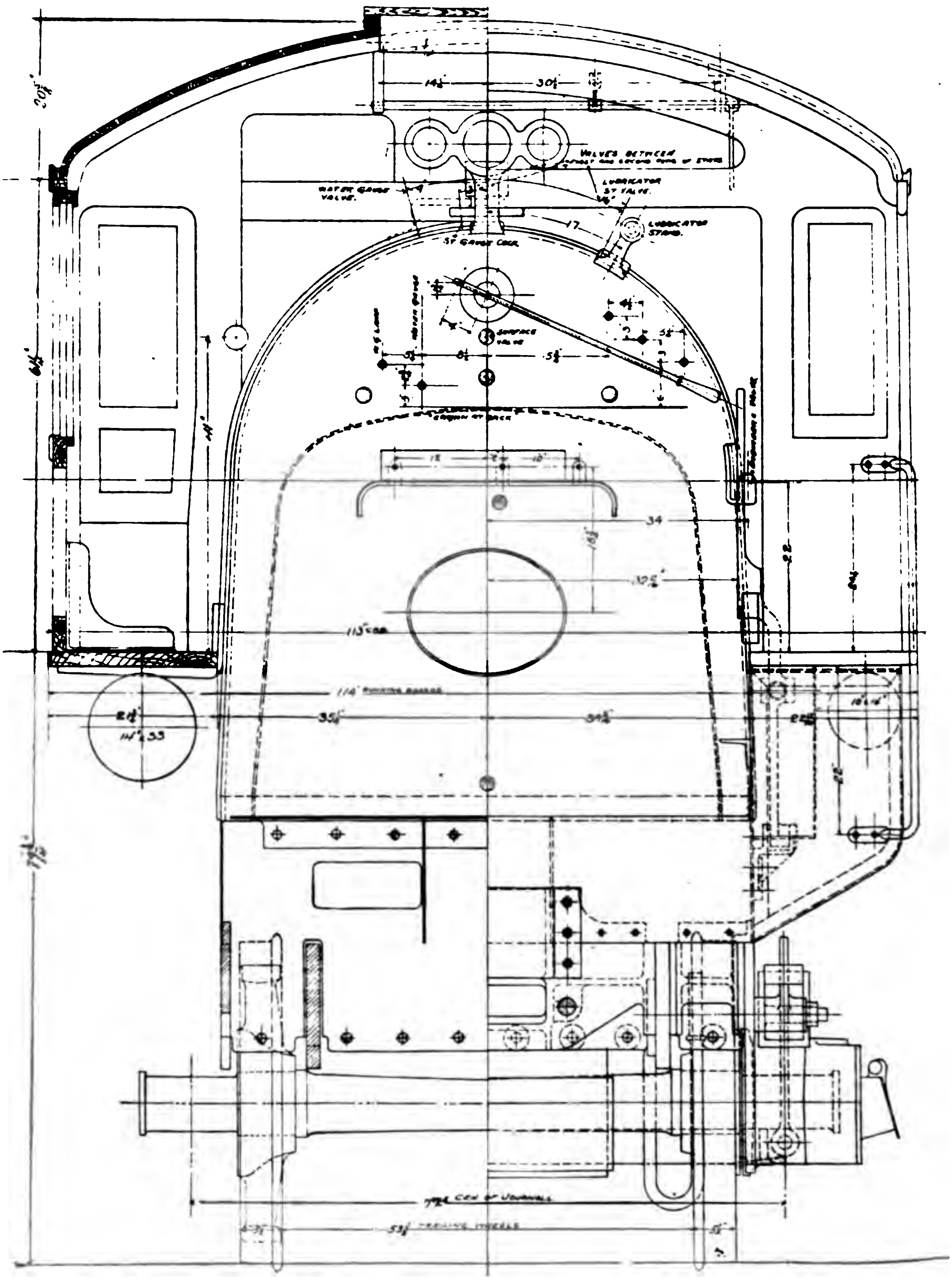

VALVES BETWEEN
WATER GAUGE VALVE
LUBRICATOR ST. VALVE
LUBRICATOR STAND.
ST. GAUGE COCK
SURFACE VALVE
114" RUNNING BOARDS
CEN. OF JOURNALS
TRAILING WHEELS

with the gauge cocks located a sufficient distance above the crown sheet, there is usually an ample margin of safety before the crown sheet can be exposed, when located on either side of the center line. Of course the vertical center of the boiler is the proper location, but on account of the throttle stem and the inconvenience to the engineer on account of distance from his side of the cab it is not customary to thus locate them.

On Wooten boilers it is always desirable to investigate the effect of maximum rolling in relation to the depth of water over the highest part of crown. If, when the engine heels over, it is found that the sides of the crown sheet are raised above the normal level of the center it is desirable either to curve the crown sheet more or raise the bottom gauge cock to give additional depth of water.

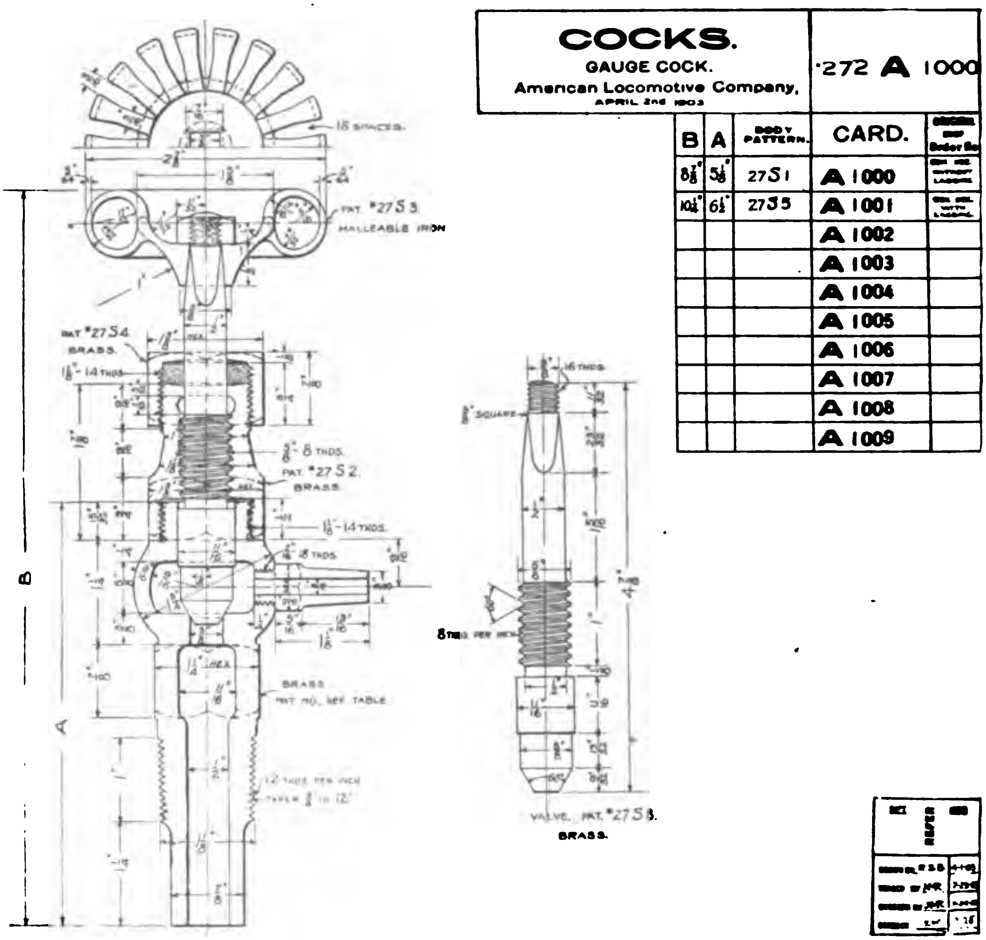
The center of the lower gauge cock is usually located 3 inches above the highest part of crown sheet, and the second and third gauge cocks 2 1-2 inches to 3 1-2 inches apart, making 5 inches to 7 inches from top to bottom cocks, according to the size and length of boilers. The water gauge should be so located that the water will just show in the glass or through the slots in the guard surrounding the glass when the water level is even with the lower gauge cock. On very long boilers and sometimes with straight top boilers, especially where they work on steep grades, it is sometimes advisable to increase the distance from top of crown to center of lower cock and allow a greater depth of water than 3 inches. The standard water gauge and gauge cock adopted by the American Locomotive Co. is shown on print 272 A 1,000, gauge cock, and 273 A 2,000, water gauge.

"The proper slope of crown sheet, expressed in inches per foot of length."

It is considered good practice to slope the crown sheet so that the front portion only will be exposed in case the water is allowed to get low. Otherwise the entire length is liable to become red hot and cause a more destructive explosion. The chances are very much in favor of the sloped sheet. A large number of cases of low water have been observed in which the tearing loose of the radial stays and bagging down of the sheet was confined to a comparatively small area at the front of the firebox, owing to the fact that the crown sheet was sloping,

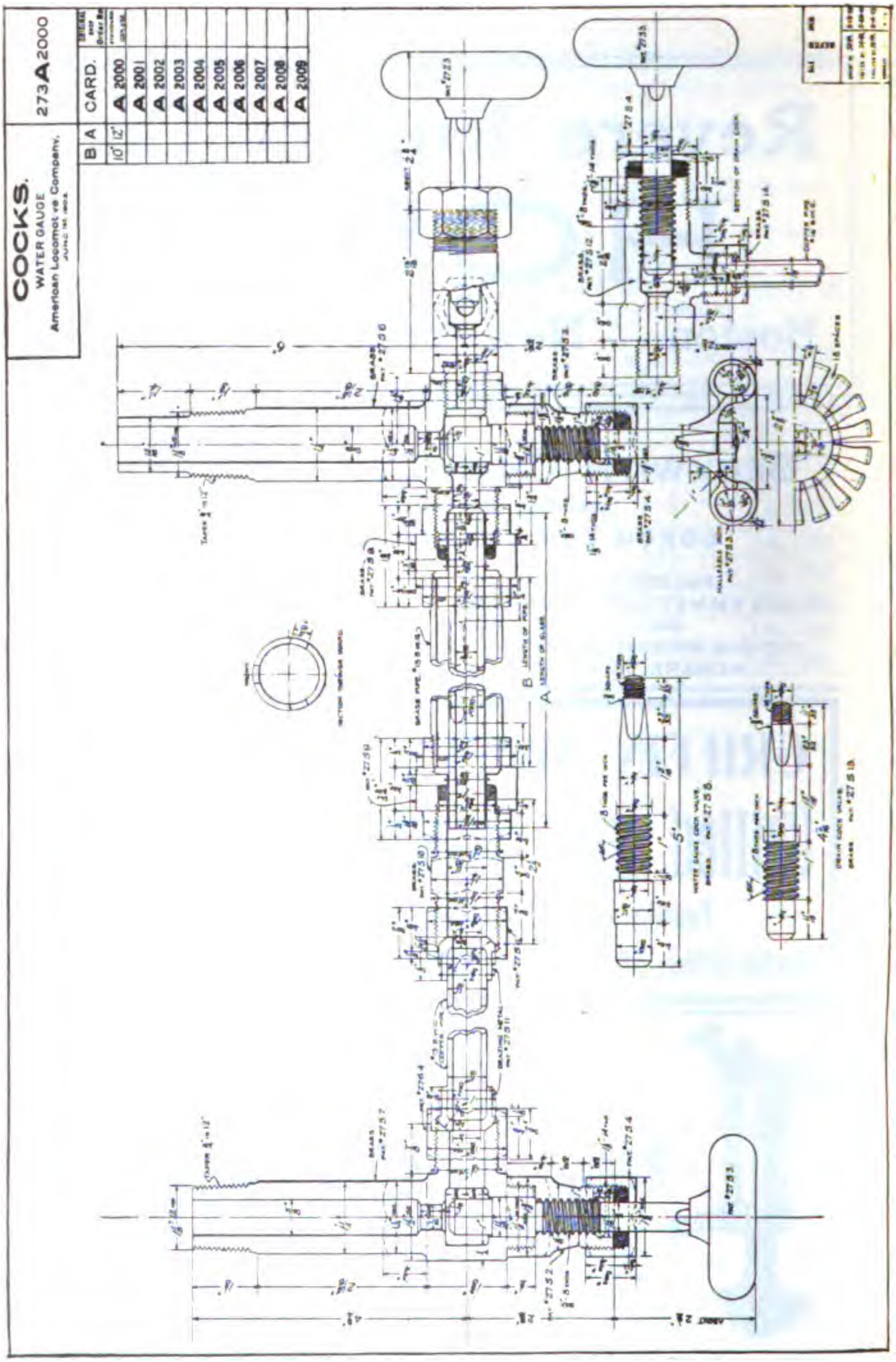
the front end only was uncovered, which became overheated and let go first, thus putting out the fire before greater damage was done.

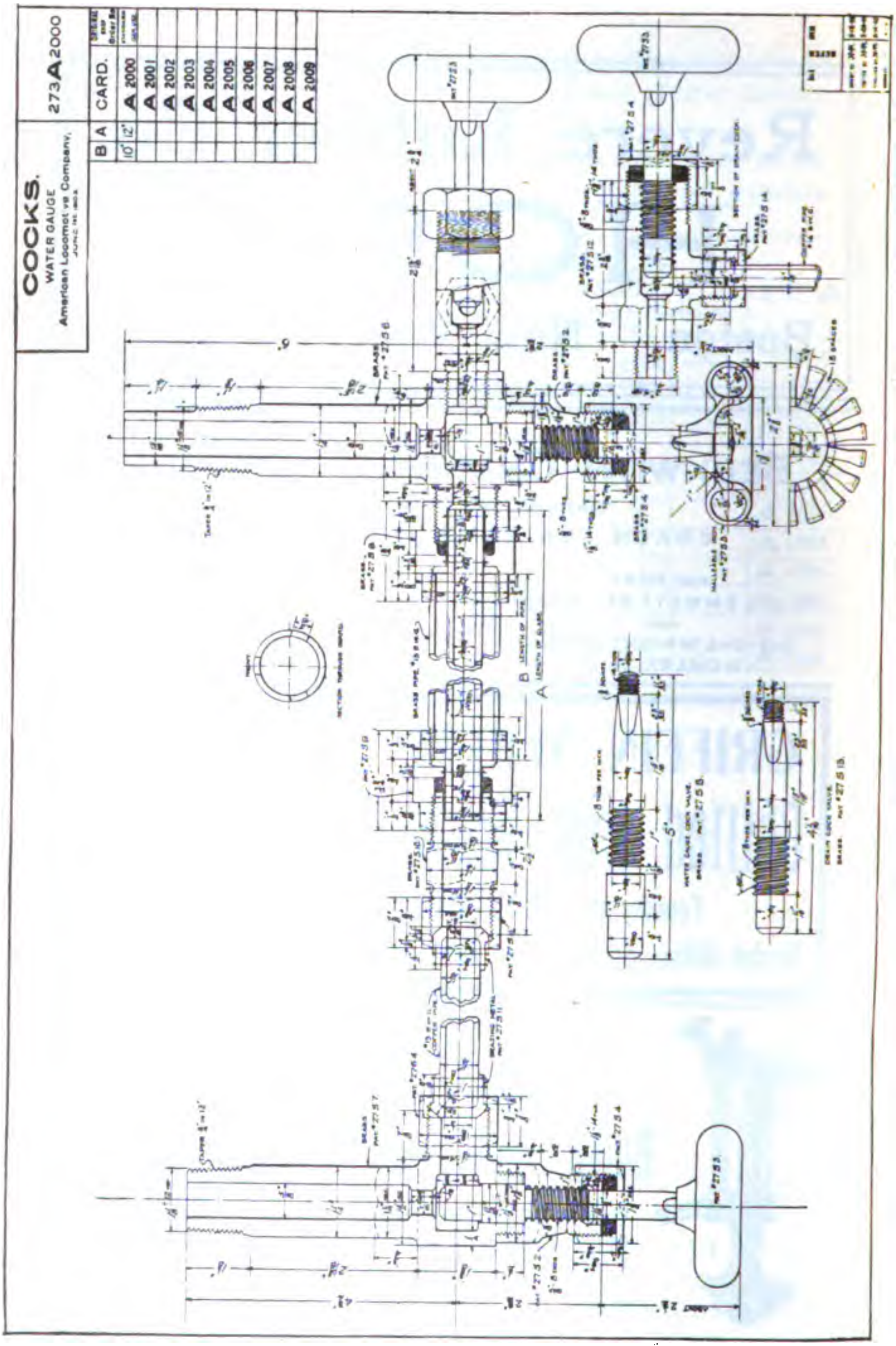
The usual amount of slope is from 3 inches to 4 inches in the total length, measured at top of firebox. 3-8 inch in 12 inches



is suggested as a suitable figure. For fireboxes 100 inches long the slope according to this rule would be 3 1-8 inches; for 108 inches long 3 3-8 inches, for 120 inches long 3 3-4 inches.

For ordinary conditions it seems unnecessary to go beyond these figures except for engines working regularly on grades


COCKS.
WATER GAUGE
American Locomotive Company.
273A2000
B A CARD.
10" 12" A 2000
A 2001
A 2002
A 2003
A 2004
A 2005
A 2006
A 2007
A 2008
A 2009


COCKS.
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exceeding 3 per cent., when it would be well to consider increasing this amount and making it slightly greater than the maximum grade upon which the engine is to run, but as the engine when ascending a grade will have an excess of water in the back and when descending with water in the first gauge cock there will evidently be a surplus of water filling the front end excessively, it is evident that the proper level of water will be preserved over the crown sheet, more by location of gauge cocks and the judgment of the engineer than the design of this particular part of the boiler. However, as a general proposition when locomotives are to work under unusual conditions, it is good practice to carefully consider what is going to happen and to study the relation of the water level to the parts of the boiler liable to become overheated.

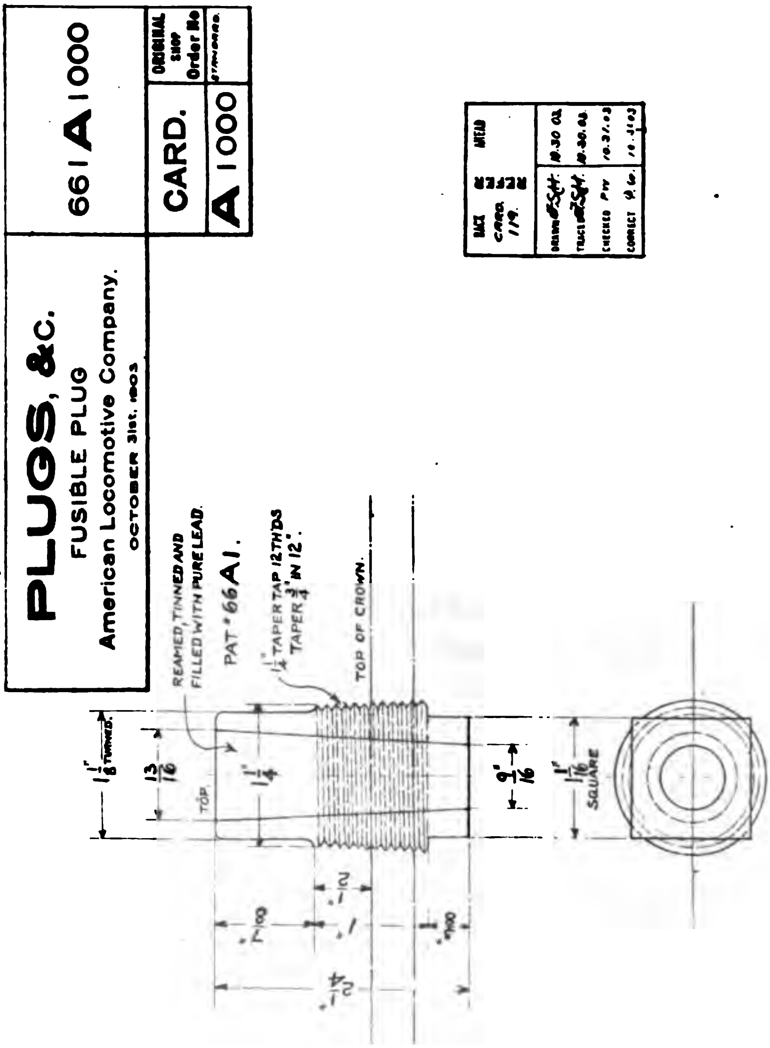
"Is the Automatic Water Detector a desirable attachment for use on locomotives?"

A fusible plug or low water detector is not generally considered necessary or desirable, nor is it essential to the safety of locomotive boilers. Unless of good design and properly filled with metal which can be relied on to fuse at a uniform temperature, it will usually prove to be worse than useless. Reliance may be placed on it and vigilance in maintaining the proper level of water relaxed under the supposition that the presence of the fusible plug will be in some degree a guarantee against low water and its usual accompaniment of an overheated crown sheet.

For this section of the country fusible plugs are applied to locomotives built by the American Locomotive Co. only to comply with the Massachusetts state law which requires their use. Railroad companies in very few cases of their own free will, require their application. Owing to the extreme heat of the firebox and the variable conditions incident to the use of locomotives a fusible plug to be of any value whatever must have very little surface exposed to the heat of the fire on the lower side of crown sheet. This necessitates a small thin hexagon head. The body should project above the crown sheet about 1 3-8 inches to keep the fusible metal well under water away from the hotter crown sheet and in order not to unduly reduce the water level and leave the crown sheet bare in case

of melting. Print 661 A 1,000 shows a good design of fusible plug.

Owing to the increase of steam pressure to an average of say 200 pounds, the melting temperature of the filling requires



to be higher than pure tin. Saturated steam of 200 pounds pressure has a temperature of 387 degrees, and the melting point of pure block tin is 421 degrees. This margin is evi-

dently too small. It is necessary, therefore, to fill them with either a composition whose melting point is between 500 degrees and 600 degrees or use pure lead, which has a melting point of 594 degrees.

The experience of one large railroad operating over a thousand engines was that unless fusible plugs were renewed every thirty days they became very unreliable and could not be depended upon. After a newly filled plug is inserted and the engine put into service the filling will commence to melt out from the bottom to slightly above the top of crown sheet, owing to the heat being conducted by the head from the portion which goes to the heated fire box before it is sufficiently reduced by the surrounding water.

The tendency then is for the hole to fill up with a hard accumulation of soot or burnt refuse product of the fuel. This in time may entirely fill up the opening, especially if small.

A hard scale frequently forms on the upper end. This can become so thick and hard, and by penetrating into the pores and crevices of the fusible metal as it partly melts and becomes somewhat porous or minutely honey-combed so as to change very materially its nature and reliability to melt at a given temperature.

Only a small percentage of the engines built at the Schenectady Works of the American Locomotive Company during the last three years have been equipped with fusible plugs.

Standard practice of this Company in this respect for use at all works is as follows:

"Fusible plugs are *not* to be applied to Firebox Crown Sheets unless distinctly specified.

In case of duplicate orders raise question.

If specified and of no particular design, use card 661´A 1,000.

EXCEPTIONS: All locomotives operating in Massachusetts must, according to State law, be provided with fusible plug."

Their use on locomotives seems to be brought about by following the practice of stationary boilers and steam boat work. The rules of the U. S. Board of Supervising Engineers for Steam Vessels requiring a fusible plug filled with block tin to be placed in each furnace at the highest point of the crown. With locomotives the conditions are entirely different, the intense heat of the firebox rendering all appliances of this kind more or less unreliable. The presence of the engineer or fire-

man continually in close proximity to the gauge cocks or water glass usually gives a close supervision over the water supply.

The concensus of opinion seems to be that in locomotive practice they are absolutely unreliable and should not be relied upon to give indication of low water. A good water gauge supplemented with try cocks are the only trustworthy appliances to indicate the height of water in locomotive boilers.

Furthermore, in the proceedings of the Railway M. M. Association for 1899 page 151, the motion was made for the discussion of subject No. 5. "Is the use of fusible or safety plugs in crown sheets advisable?" and the following resolution was approved as the sense of the meeting: "That the use of fusible plugs in crown sheets of locomotive fireboxes is not conducive to overheating of crown sheets."

"Destruction of side sheets in wide fireboxes and reasons therefore."

In reading over this query it seems to imply that the side sheets in wide firebox engines are more liable to failure than in other forms of boilers. Such, however, does not seem to be the case, and while a number of reports calling attention to the cracking of sheets in wide fireboxes has been noted, yet on investigation it is not at all a general complaint, but confined to certain roads and local conditions.

The cracking of side sheets is a difficulty, and by no means a new condition, which has always been present since locomotives of any size have been made. It can safely be said that in the majority of cases it is caused by overheating, either by the accumulation of scale, which does not permit the water to carry off the heat fast enough or by deficiency in width and design of water spaces, impeding in some way the circulation of water. When this occurs the water is liable to be driven away from the side sheets, steam forming in pockets and temporarily taking its place. This has shown conclusively by a number of tests, notably those published in the American Engineer & R.R. Journal in June, 1903, in which gauge cocks having shanks of various lengths were screwed into the water spaces from the outside, extending to within 1-8 inch to 3-8 inch of the firebox side sheets.

The report reads as follows:—

"We have completed our test of Engine No. —, to determine the dryness of steam adjacent to the firebox. We first used glass water gauges on the sides, but these showed water at all times. We next placed gauge cocks with extension tubes on the sides, about midway of the length of the firebox, the lower gauge

being about 16 inches above the mud ring, the second 6 inches higher, and the fourth gauge about 40 inches above the mud ring. The ends of the extension of the gauge cocks projected through the water space to within 1-8 inch of the water side of the inside firebox sheet. These extensions were gradually shortened until the ends were 3-4 inch from the inside sheet.

"We find from this experiment that when the engine is working hard there is a zone of practically dry steam covering the central portion of the side sheet; that is to say, the evaporation is so rapid that the sheet under these conditions is at times dry. The zone appears to start at zero and increase in thickness as it extends upward. At the center of the sheet there is about 3-4 inch of practically dry steam. It is not constant, nor is the distance from the firebox a fixed one, but it various as the fire is pushed and the height of the water increases. It appears that the zone is thicker when the water is low. The sudden lurching or swaying of the boiler appears to throw water against the sheet. This is evident from the fact that there may be a steady flow of steam for a few seconds, then water and so on. Upon opening one of the cocks water will flow, later steam. If the cocks are left open, it seems as if a suction is produced on the inner end of the tube which draws the water out.

"On new engines this road has had many cracked and bulged side sheets The cracks are nearly always vertical and the steel is covered with minute cracks, parallel and vertical, very closely resembling burnt steel; yet the steel was satisfactory under tests. The cracks have developed in the roundhouse when firing up or washing out. They are ofter accompanied by loud reports, indicating high internal stresses in the firebox structure. These facts indicate the necessity for a thorough study of firebox conditions, and they point to the importance of improved circulation."

In these tests it was shown that steam instead of water was present in certain locations. It seems to be pretty well proved that frequently with the intense heat often generated in locomotive fireboxes the side sheets are alternately overheated and cooled, as the water is in contact or is driven away. This, I think, in a general way, explains the reason for the cracking of these sheets and it has not been proved that the wide firebox engines are more subject to this than the narrow and older forms. Owing to the straight water spaces and greater freedom for circulation of water it is thought that the side sheets in wide fireboxes would not become so easily overheated. Furthermore, the length of the firebox having been decreased is a distinct advantage, the tendency recently having been to increase the water spaces allowing much more than was possible on boilers with narrow fireboxes. It is therefore believed, that owing to there being no restriction due to frames, wheels, etc., the trouble which has been experienced in the narrower firebox will largely disappear in the wider ones, except in cases

where the overheating is caused by the formation of scale and even then the great advantage due to the accessibility of the washout plugs in wide firebox engines leaves no excuse for this work being slighted in the round houses. With fireboxes back of the frames and wheels, expansion pads, etc., it was often a very difficult matter to clean out thoroughly the water spaces around the firebox and one of the advantages of the wide firebox engines is the comparative ease with which this work can be done, so that accumulations can be easily removed without taking down a number of parts, and at the same time ample room is allowed for the use of all forms of washing out nozzles, cleaning rods, etc.

"THE BEST FORM OF RADIAL STAYS."

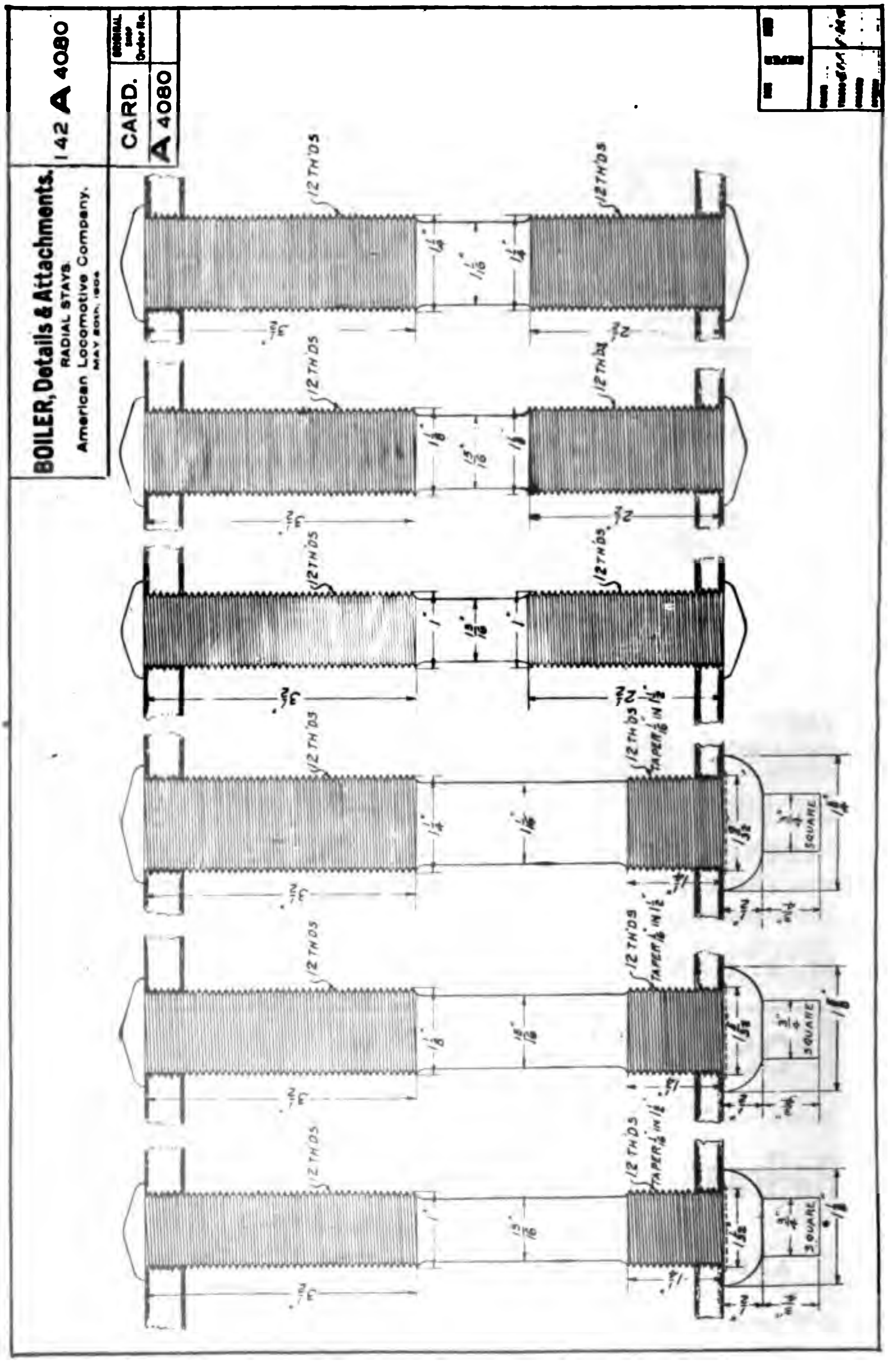
There is some difference of opinion existing on this subject, and there can be found advocates of the three forms of Radial Stays which are at present more or less in common use, these are:

Radial Stays with Solid Button Heads;
Radial Stays with Nuts on lower ends;
Radial Stays which are riveted over at the lower ends.

While local conditions may occasionally make it apparent that some one of these forms is more desirable than another, yet the concensus of opinion and their use in a majority of the number of engines built, proves conclusively that the style of Radial Stays most in favor at the present time, is the one having a solid button head and screwed into the crown sheet, with a slight taper in the thread under head, twelve threads per inch, the head being faced off so as to bear on the outer edge. See sketch 142 A 4080.

In tapping out the sheets, care must be taken that the hole is at right angles to the sheet so as to allow the button head of the bolt to be screwed up solidly and squarely against the sheet without the use of copper washers.

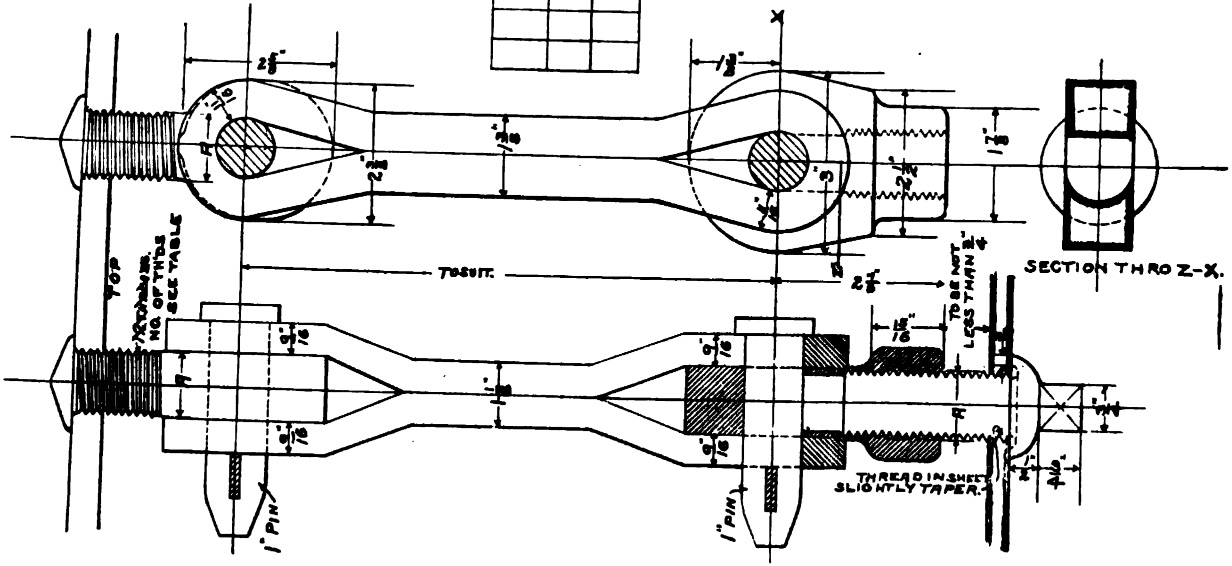
This form of stay is used on the 6 to 10 center rows which are located exactly radial to the surface of the sheet, so that the button head can seat squarely against its lower surface. While in bad water districts, some trouble may be experienced occasionally from this form of stay, yet the safety of it has been


BOILER, Details & Attachments.
RADIAL STAYS.
American Locomotive Company.
MAY 20TH, 1904
142 A 4080
CARD.
A 4080
12 TH'DS
TAPER 1/16 IN 1 1/2
SQUARE

EXPANSION STAY.

SCHENECTADY LOCOMOTIVE WORKS
TRACED BY W R G. MAY 6th, 1901.

	CARD	A	NO. OF TH'DS
ENG. 5926.	23	1 1/8"	12TH
GEN. USE	27	1"	12TH.
26143.	65	1"	11TH.
26270.	68	1 1/8"	11TH.



abundantly proved. In cases of low water the crown sheets have frequently been observed to have been pulled off the riveted stays at the sides and only held from causing a destructive explosion by the button-head stays.

Of course, the first tendency in an overheated crown sheet is to bag it down between the stays, stretching the holes and causing leaks around the stays. With the use of the riveted stays, the argument is that they can be riveted over and the engine put in service again. While this is partly true, yet if the sheet is scorched to any great extent, or bagged down, it is better practice to remove the stays, re-tap the holes and insert new stays.

Owing to the upward expansion of the tube sheet on firebox sheets when the boiler is first fired up, before steam is generated, it is desirable to place at least three rows of expansion stays at front of firebox. A good design is shown on blueprint of Expansion Stay Card 23, in which button-head stay having the same style of head as the solid radial, is screwed in a taper hole from underneath, into a drop forged lug. A lug with screwed end secures the stay to the roof, intermediate connections being made of 11-16 inch square, welded up with jaws at either end, the whole being connected with 1-inch pins secured with flat keys. This form of stay makes a very light, strong construction and allows freedom for expansion.

"The boiler tubes with special reference to length, arrangement and spacing to improve the circulation and reduce the trouble from leaky flues."

The question of tube spacing must be determined for each case largely by the quality of water which will be used. With good water, which is so often found in the Eastern States, it is entirely practicable to build locomotive boilers with flues 16 feet and over in length with only 11-16 of an inch spaces. No particular trouble is experienced in boilers having this spacing from raising water, nor is there any evidence available to show that the life of the tubes is decreased by insufficient circulation or overheating.

A designer of locomotive boilers has always two facts before him. One is the advisability of making large ample water spaces around the firebox and between the tubes, and the other is the ever present demand for more heating surface. It has

not been proved that increasing the water spacing between the tubes when good water is used will eliminate the leakage or even very materially improve the difficulty in all cases, nor will it greatly increase the life of the tubes. It would be an entirely erroneous conclusion to jump at, that by merely increasing the spacing and consequently decreasing the heat surface that the trouble from leaky flues would disappear.

In a general way the increase or decrease of heating surface due to differences of 1-16 inch in the spacing of flues makes about 4 1-2 per cent. loss or gain in the heating surface. This is given in the table below for different spacings varying by 1-16 of an inch and may be found useful in determining the best arrangement to use for different conditions.

BOILER TUBES.

Relation of Heating Surface to Diameter of Tubes & Spacing.

Diameter.	Spacing.	Centers.	Ratio.
1 1-2 inches	5-8 inch	2 1-8 inches	1.256
1 3-4 "	5 8 "	2 3-8 "	1.174
2 inches	3-4 "	2 3-4 "	1.
2 1-4 "	3-4 "	3 "	.945
2 1-2 "	3-4 "	3 1-4 "	.895

Loss in flue area.

2 inches O.D. 2 3-4 inches centers, No. 11 B. W. G.
2 1-4 " O.D. 3 " " No. 11 "

2 inch flues 8.7 per cent. loss over 2 1-4 inches.

Loss or Gain due to Increased or Decreased Spacing.

3-4 = 1.

2 inch Tubes.		2 1-4 inch Tubes.	
Spacing.	Ratio.	Spacing.	Ratio.
5-8 inch	1.097	5-8 inch	1.088
11-16 "	1.047	11-16 "	1.04
3-4 "	1.	3-4 "	1.
13-16 "	.956	13-16 "	.960
7-8 "	.915	7-8 "	.922
15-16 "	.876	15-16 "	.885
1 "	.840	1 "	.852

As a general proposition it does not seem desirable to increase the spacing more than 7-8 inch as no corresponding

gain appears to be attained and much useful heating surface is lost. In wagon top boilers, flues can often be arranged to better advantage by making a greater spacing in firebox than in the front end and as the greatest evaporation occurs at the firebox end of the flues therefore it would seem desirable to do this whenever additional heating surface can be obtained. For water containing much incrustating matter it would seem desirable to place the flues 7-8 inch apart; that is, 2-inch flues should be spaced with 2 7-8 of an inch centers and 2 1-4 inch flues with 3 1-8 of an inch centers. Where engines are transferred from one division to another, and the water may be good on one division and bad on the other, it is often desirable to space the flues in this manner, but where the engines are used entirely in good water districts, 3-4 of an inch spacing is ample.

In recent years the length of tubes has gradually increased owing to the introduction of wide fireboxes, Atlantic, Pacific, Prairie and other designs of engines requiring longer boilers. No particular trouble seems to be experienced with these long flues and from the reports available indications are that the mileage is almost as long as for the shorter ones. Nor is there any unusual trouble experienced by their use from leakage. Owing to the increased frictional resistance of the gases in passing through long tubes, it would appear desirable to increase their diameter as the length increases and, while the reports on this source are somewhat conflicting, it seems to be good practice to use tubes 2 1-4 inches in diameter for lengths exceeding 16 feet. This again, however, is a matter which must be controlled by local conditions and the steaming requirements, as with the larger tubes some loss of heating surface occurs and the same amount cannot be obtained as with smaller diameters.

In our practice the best results are obtained when the stand ard A. L. Co. method of tube setting is used. Copy of standard practice card relating to this matter is as follows:

TUBE SETTING.

Use the following method of tube setting:

HOLES: Punch lead holes to suit guide pin in cutter; bore tube holes in firebox sheet exact outside diameter of tubes. Bore tube holes in front sheet 1-16 inch larger diameter than tubes. Holes must be perfectly smooth and reamed if

necessary. Chamfer both edges of holes to a radius of 1-16 inch with suitable rosebit made to fit bore.

Both sheets to be properly straightened *before* tube holes are bored.

FERRULES: Use on firebox end only, and of the same outside diameter as holes, and 1-16 inch to 1-8 inch longer than the thickness of sheets; thickness No. 16 B. W. G. ferrules to be lightly rolled in sheet before tubes are inserted.

Standard sizes of ferrules: 2 inch and 2 1-4 inch O. D. x No. 16 B. W. G. x 5-8 inch and 3-4 inch long for sheets 1-2 inch and 9-16 inch and 5-8 and 11-16 inch thick.

TUBES: To be cut not less than 1-4 inch or more than 3-8 inch longer than gauged distance over both tube sheets.

To be swaged to 1-8 inch less diameter than tube at firebox end, and expanded to 1-16 inch greater diameter than tube at front end. Both ends to be annealed.

Scale to be thoroughly removed from both ends before insertion.

SETTING: See that all tubes are clean, insert tubes and set in the following order:

1. Turn ends of all tubes on back and 10 per cent. in front.
2. Round up ends with Mandrill.
3. Prosser thoroughly on back end and beaded tubes on front end. Inspect carefully.
4. Bead over all ends on back and 10 per cent in front. Use pneumatic hammer.
5. Roll both ends carefully, preferably with pneumatic tool.
6. Re-roll firebox end *lightly*, when required, after boiler has been fired up and tested.

NOTE: Where R. R. Co.'s requirements vary from above, raise question.

The workmen are familiar with this method and the results obtained confirm us in this opinion.

Whether to use the Prosser expander or set tubes entirely by rolling is a matter which is often discussed by railroad men, but at the present time, as far as we are able to learn, and certainly in our own practice, the best results are always obtained by judicious use of the Prosser expander. The prejudice, or whatever it may be called, against its use has, in our opinion, in some cases been entirely occasioned by its excessive use in the hands of inexperienced or careless workmen.

THE PRESIDENT: As the other subject of the evening is entirely foreign to the paper that has just been read, I think it advisable that we take up the discussion of the paper on Boiler Design at this time, after which we will proceed to the second paper. Gentlemen, we want to hear something about what you know of boiler design. You will remember that the paper is

under six headings: (1) Gauge cocks; (2) the proper slope of the crown sheet; (3) the automatic low water detector; (4) the destruction of side sheets; (5) the best form of radial stays; (6) the tubes. I don't want to repeat what I have said here on previous occasions, that if the gentlemen don't stand on their feet willingly I shall have to assist them. We are waiting for some of the locomotive men present to tell us something. No one seems to start the ball rolling. As this paper came from an American Locomotive Company man I would be very glad to hear from Mr. White, of the Manchester Locomotive Works of the American Company.

MR. A. M. WHITE: I don't know that I can say very much more than Mr. Cole has said. The practice that has been outlined is, I know, that which is followed at Schenectady and generally by the other plants. A great deal depends on good workmanship, as much on that very often as on design, and that is a matter that is continually watched. They are continually looking to see that the workmanship is right, inspecting and examining all through. The difficulty with side sheets is one that is just as old as the boiler. They have always had trouble with them and there is no question at all that the trouble is due to the driving away of the water at times by the intense heat. In time that will crack the sheet. As all railroad men are aware, these cracks very often start from around the stay hole. That has been attributed to the fact that they were punched. That is now however almost entirely done away with. Nearly all fire box sheets are drilled and then the holes are well reamed. That takes out nearly all the checking that comes from the punching. The tube setting is another thing. There are probably as great a number of ways of doing that as there are different boiler makers. When the companies that form the American Locomotive Co. came together we found that there were hardly any two of the concerns that set the tubes alike. It has been a matter that they have been investigating pretty carefully since the formation of the company, to get something that would answer in every condition, and what Mr. Cole has outlined is the practice that is being generally followed. I often think of the people in the East as compared with those in the West, of the good water and the little boiler troubles that

the people in the East have. You are all acquainted undoubtedly, with the troubles that they have in the West, where they have alkali water. In the East it seems good to me to get into a shop and find that they don't have much trouble with the boilers, for in the West they have to take out the flues every few months—hardly every few years, it is sometimes less than a year. I have seen fire-box side sheets that had to come out in eleven months, the water being bad. They have nothing against builder or against the material. The material, analyzed, was all right. So far as the design of boilers is concerned, it was thought that when they got in a wide box there would be somewhat less trouble than there had been with the narrow box—I refer to the deep box that goes between the frames, — the grate area being larger, there would be less necessity for the intense heat. But practice does not seem to have ever borne that out. There is some trouble now with the wide box, but I do not think as much as there has been with the deep narrow box. Concerning the leakage of flues in the wide boxes, our observation has been that there is very little difference between those and the narrow boxes. I don't know that I can say anything more. These matters are ones that have been a life study, almost, with those who are building engines. Every little thing has come up. There have been all sorts of ideas advanced and experiments made.

THE PRESIDENT: I haven't a doubt there are some gentlemen here tonight whose business relates particularly to the repair, manufacture, or maintenance of boilers. It appears to me that upon receiving a card with the announcement of a paper on boiler design, they would be interested enough to come to the meeting. I see some faces here tonight that I don't see regularly, and that makes me believe all the more that they are here, and I would like to hear from them. We would all like to hear from them. This is a very serious subject, gentlemen, and it is one that has been threshed over time and time again. As Mr. White says, the men who build engines have given it a life study, and I think we have not arrived at perfection yet,— either in the manufacture or the maintenance. Perhaps some of the engineers here would like to say something about the location of water glasses, gauge cocks, fusible plugs, etc.

Mr. E. E. Potter: One seems to be waiting for the other, and so, until somebody else gets up, I thought I would say a word. I was thinking about the location of the soft plug as stated in the paper which has been read. I understand it is located in the shallowest part of the sheet. Did I understand that right?

The President: That is, the high point of the crown sheet.

Mr. Potter: The sloping sheet. Now, I was thinking, if the water doesn't come pretty close to that plug, at times when we apply the brake in an emergency, especially in going down a steep grade. I have a water glass on my engine, and with two or three gauges of water in the boiler, going down a grade say 60 feet to the mile, with your brake in the emergency to save some poor devil's life on the track, that water will go out of sight and stay out of sight for 15 seconds. I don't know how far it goes. Possibly it may go down nearer the crown sheet than we think for. Now, how long has that soft plug got to be bare before it will melt? It melts at 540 degrees, or something like that. How long do you think that the water would have to be off of that plug before it would melt?

The President: Do you ask me that question?

Mr. Potter: Yes, or the gentleman who read the paper.

The President: Well, it would depend considerably on the length of time that the plug had been in service, as explained in the paper, the soft metal being melted out a portion of the distance of the fusible plug by the intense heat of the fire being applied to the metal below the sheet and in the sheet.

Mr. Potter: Then if the plug had been in there a good while it would probably take more than 500 degrees to melt it, wouldn't it?

The President: The inference from the paper is that it would.

Mr. Potter: Well, I was wondering if engineers didn't sometimes have their water closer to the crown sheet than they realized under those conditions that I speak of. I think they do. I have been running an engine several years and never lost a fusible plug yet; I don't intend to. But the reading of the paper suggested the above thought. And

another thing, speaking about leaky flues, in the long fire boxes there is the greatest trouble. We have in those big engines 9-foot fire boxes. Now, carrying 200 pounds of steam on the road, when we reach the terminal, of course we run the steam down, say, to 120 pounds; we arrive on the spark track ash pit, and the men get on and open the door; so much dirt they do not find much fire there, and put on the blower wide open, drive the cold air through. When through cleaning, if they don't leave fire in the forward end of fire box the flues will begin to leak before morning. That will happen nine times out of ten on the engines with the big fire box. But by bringing in a pretty good fire and keeping it well ahead, it will keep the flues from leaking. I think if more care was taken with engines on ash pit, relative to what I mentioned, it would reduce necessary repairs more than 50 per cent. on leaky flues.

THE PRESIDENT: I would like to ask Mr. White if I expressed the inference of the paper in regard to the question asked by Mr. Potter?

MR. WHITE: Referring to the —— ?

THE PRESIDENT: Fusible plug.

MR. WHITE: The danger of the plug becoming choked?

THE PRESIDENT: Yes.

MR. WHITE: I think you have. I was going to ask, before the discussion was over, if there was any one here who had observed that the fusible plug would become choked up in the lower end, and if, when the plugs were taken out, removed to put in others, after they had been in a long time, there was any soft metal left in the plug. I have seen them where there has been very little metal in the upper portion, all burned away below and choked up. It did look as though, had there been sufficient heat applied to melt the soft metal, still it would not have gone down, or would not have opened up. I would like to hear the experience of men who have had those to deal with. You must remember that we as builders only know the beginning, we don't always know the end. We are continually looking for it, and we like that information.

MR. POTTER: I was not looking for information, you know, with a view to running the water lower than I had previously done. But all engineers don't have a water glass; a good many

don't like them, I am sorry to say. On some divisions an engine can go down there equipped with a water glass, and it may not last more than a week. When it breaks that settles it. They don't put any more in. They don't like them. Now, I do. A good many engineers never had them, and they don't know how low the water goes sometimes, with brake applied hard. You put your brake on in service or an emergency, and going down hill your water goes in the forward end of the boiler. If the engineer had a water glass where he could look at it, it might scare him sometimes. I am referring now to engines whose bottom gauge cock is not far above crown sheet.

THE PRESIDENT: You don't infer by that, Mr. Potter, that it is a good thing to scare an engineer, do you?

MR. POTTER: An engineer is never scared. I should have used the word *surprised* in my previous remark instead of *scared.*

THE PRESIDENT: I would like to have some practical railroad man here — a good round-house man — answer Mr. White's question, whether or not they have removed fusible plugs and found them practically empty of the fusible metal. Why is it that we cannot get some of you men on your feet? Mr. Fries, I don't know that we have heard from you since you came East. Gentlemen, this is Mr. Fries of the Boston & Albany road, and we want to hear him talk on Boiler Design.

MR. A. J. FRIES: A few years ago I was connected with a road in the West which bought six engines from an eastern road, the Old Colony road of Massachusetts, and the engines all had fusible plugs in the fire boxes. Two of them were badly burned, in other words, the plugs did not save them, and the metal was found intact in the plugs after the damage was done. Since coming East I have seen not less than two crown sheets saved by fusible plugs, or, in other words, there was very little damage done to them by low water. The metal melted properly in the plugs and killed the fire. This leads me to believe that fusible plugs are a good thing in good water districts and a poor thing in bad water districts. Now, there is another thing in the paper that I might refer to. For instance, the distance of the lower gauge cock from the crown sheet is given as three inches. I don't think that is enough for practical purposes. I think that the lower gauge cock should be located not less than four inches

from the highest part of the crown sheet. I don't think of anything else just now that I want to say anything on.

THE PRESIDENT: Before you sit down, Mr. Fries, I would like to ask you in regard to prossering flues. I think you can tell us something about that.

MR. FRIES: The practice that the paper outlines is practically what is being followed on the New York Central system now, that is, west of Boston. It is not being followed in Boston. I don't know whether it is in Springfield or not; but on the main line the practice as outlined there is practically being followed as the result of some very long experiments that were conducted there by a committee appointed for that purpose about two years ago. They claim to have better results with flues now, or less flue leakage than ever before in the history of the road. The prosser was largely used at different points on the road in a different manner. Some of them used the prosser last, others used it first, that is, some would use a prosser tool first and a roll afterwards, some would roll first and prosser afterwards. But they finally came down to prossering. They roll very little now, and roll last.

THE PRESIDENT: Do you think there would be more danger from the prosser in the hands of a poor workman than there would be from the rolls, or *vice versa?*

MR. FRIES: Well, either is bad in the hands of a poor workman, either the prosser or the rolls, but I don't think there is any more danger with the prosser then there is with the rolls. I have never seen any bad results from the use of the prosser.

THE PRESIDENT: Is there a Boston & Maine man here who would like to say something? I saw Mr. C. B. Smith come in the door a little while ago. Mr. Smith, can't you favor us?

MR. C. B. SMITH: Mr. President, the topics as presented in the paper are not those which I had expected when I came this evening. However, the paper has been very interesting and instructive, and I think that, so far as our practice on the Boston & Maine is concerned, I can approve of practically all of the principal points made by Mr. Cole. I had hoped that there would be some points brought out with reference to "radial stays *vs.* the use of T bars" and the use of "flexible stay bolts" and more said upon "thicker side sheets" than

there has been. With reference to flue spacing, I am glad to know that Mr. Cole takes the stand that there should be wider spacing of tubes at the fire-box end, for it has seemed to me for some time that in large modern high-pressure boilers a wider bridge is needed, not only for freer circulation, but to furnish extra strength for the time when tube renewals, enlarged tube holes and wasting of the plate greatly weaken the bridges. In this connection there seems to be a point relating to the use of the Prosser expander. Has it not been found that the use of the Prosser expander in old tube sheets is more detrimental than in new sheets, and that the excessive expanding process with the prosser in the old tube sheet has a tendency to stretch the holes out of a true circle and make it more difficult to make the tubes tight. So far as the Boston & Maine practice is concerned, the Prosser expander is not used at all, certainly not at the Boston shops, and I am very sure that at other shops on the system they do not favor the use of that tool, and it has not been satisfactory with us. Soon after the receipt of some broad fire-box engines having the gauge cocks located in the corner of the backhead, I found many engineers who were suspicious of the action of the water as it appeared at those gauge cocks. They believed that the water tended to exhibit a higher level than the actual level at the gauge cocks so located than if the cocks were in the backhead or on the side, and this seemed to be true in some instances. These gauge cocks were located, as I said, in the round of the backhead, and there appeared to be a tendency to indicate a higher water level with cocks so located. Perhaps these cover all the thoughts which I had.

THE PRESIDENT: I should like to ask Mr. Smith just a question for my own satisfaction. Did you ever find on any of your larger engines — the engines of the class of the battleship — that the gauge cock and the water glass failed to agree, that is, there was a material disagreement between the two?

MR. SMITH: If my memory serves me correctly with regard to those particular engines, there was a disagreement in the height indicated by the gauge cock and the water glass; but it should be explained that where the gauge cock enters the corner of the backhead it stands at an angle, *i. e.*, on a radial

line, and I think that the delusion — for it was a delusion — was due to the fact that the end of the cock was actually higher than the opening which that cock made at the entrance to the boiler, and to that extent it deceived the engineer. I think that was the probable cause of the belief that there was a difference of level as indicated by the water glass and the gauge cocks in the corner of back head.

THE PRESIDENT: Then, according to your explanation, the gauge cock would show water when the water glass would not show it at that level. Is that it? The gauge cock being a little higher, it would show water higher up than the level of the water glass?

MR. SMITH: Yes.

THE PRESIDENT: You never found a water glass to show "full" when you could not find any water at all in the cocks, did you?

MR. SMITH: Well, it so happened that on those particular engines, having a straight top boiler and running on a hilly division, it was found that high water could not be carried satisfactorily, and hence, at times when water was allowed to disappear at the top of the gauge it usually resulted in water in the cylinder. Enginemen soon learned that they could not carry the water at such a height. While I am up again I would like to say that it is our practice with reference to fusible plugs, always in repairs to renew them. I think my foreman boiler maker, who is present, will bear me out in the statement that corrosion appears, and he always feels it is safer to renew these plugs. Am I not correct, Mr. Galligan?

MR. GALLIGAN: Yes.

MR. POTTER: I would like to say a word about the water glass agreeing with the gauge cocks. I think the water glass should be blown out every day to keep it in good working condition. I have had one on an engine now six years, and I never knew it to fail to agree with the gauge cocks. But if you don't take care of it it won't agree. Mud settles around the valves there, you know, and if it is not taken care of there will be disagreement. I have taken other engines, sometimes spare engines, for a run, and the water glass would not tally with the gauge cocks. But blow it out, keep it in working condition

and it will tally every time. I don't believe in keeping water too high or too low in a locomotive boiler while running on the road. I find I get best results by keeping not more than steam and water in the top gauge while throttle is open using steam, for when engine is shut off the water will easily drop to the second gauge. In this manner you get the benefit of superheated steam in your steam chest and cylinders, and that's what gets you over the road on time, with no delay reports to put in at the end of the run.

THE PRESIDENT: I would like to call on Mr. Cleaver, Superintendent of Motive Power of the Rutland Railroad, who is seldom with us. I think we should be glad to hear from him tonight. Mr. Cleaver, can't you favor us?

MR. F. C. CLEAVER: I came here to listen to the others talk, and not to talk myself. I might reverse the order of things and give you the last information I have about the cause of trouble with the boilers. Coming into your town this morning, I noticed an engine of somewhat peculiar construction, and got into a talk with the engineer about it. After we had settled on some points about it I asked him, among other questions, if he had any trouble with leaky flues with that engine. He said he did. Going into the matter a little further I found that the engine had a double crew, one day one engineer and fireman ran it, and another day another engineer and fireman ran it. The engineer with whom I was talking did not have much to say about the other engineer, but he said, "The other fireman is not as good as my fireman. My fireman, when he goes to the ash pit, always has a good fire in there, and he has a good fire up against the flue sheet. It sometimes happens that I run that engine several days in succession, and we don't have leaky flues. The other fireman takes the engine to the ash pit with little or no fire, and the indications are that the leaky flues start from him." I am just speaking of that as an illustration of the fact that the personal equation has much to do with the trouble we have with the fire-boxes and flues. I know that to be a fact. I have experienced it so many times with engines of exactly the same class, exactly the same service, on the same division, run by different men. One will do good work and give little trouble with leaking, while the other will do just the opposite. We

cannot assign it to any other reason than the men who operate them. I don't mean to say that there are men who intentionally cause these troubles, but either from not knowing or from indifference they do cause them. I think we frequently ascribe to construction faults that are due to something else.

THE PRESIDENT: Has any other gentleman anything to say in connection with any of these classes?

MR. A. H. ELDRIDGE: I should like to say a word about those fusible plugs. I have been interested in them. I would like to know whether any tests have been made to show how fast they deteriorate, or at what temperature they melt out after they have been used thirty days or sixty days. I don't know of any such test. I simply wanted to suggest that if the people here who are interested in that matter — not too many of them, but a few of them — would send me samples of these plugs, giving the date, and how long they have been used, and their address, I think I can get them tested for them, and we will get some information regarding the life of the fusible plug.

THE PRESIDENT: That is a very kind offer, and I think it would be advantageous to more than one if some of the members would comply with the suggestion. I trust they will avail themselves of the opportunity.

Any other remarks? If there are no further remarks I would like to ask Mr. White if he would care to say anything to the paper in closing, in the absence of Mr. Cole.

MR. WHITE: I have nothing more that I think of.

THE PRESIDENT: In that event, and no further discussion appearing, we will consider this discussion closed, and I so declare it. The next is a short paper on Passenger Car Interchange, to be presented by Mr. Frederick A. Carr, the Chief Clerk of the Car Department of the Boston & Maine Railroad. I have the pleasure of introducing Mr. Carr.

PASSENGER CAR INTERCHANGE.

By FRED'K A. CARR.

My subject is one which occupies its share of the thoughts of those whose duty it is to account for the expenses of the maintenance of Passenger Equipment which are operated in

Line Service, or, as it is frequently called, Passenger Car Interchange, and who consequently realize the urgent need of a code of rules defining that interchange and thereby producing uniformity in practice and accounting, the need of which was the principal motive in the organization of the Master Car Builders' Association. It is a subject which, while Freight Car Interchange has been discussed and agreed upon and discussed again, has been neglected and forgotten; and, as a matter of fact, the interchange of passenger equipment between connecting railroad companies has never been made the subject of a complete code of rules from a Car Department standpoint, and on this account misunderstandings and controversies as to practice and responsibility have resulted.

As a matter of fact, few roads make any attempt at complete accounting for line operating expenses of ordinary passenger and baggage equipment but confine themselves exclusively to accounting for operating expenses of Pullman equipment (cleaning, lighting, lubrication, etc.), principally for the reason that the expenses incident to that equipment are usually greater (especially as to cleaning) than is true with reference to ordinary coaches and baggage cars.

The M. C. B. Passenger Code of Rules touches upon the matter of interchange but it is not of sufficient scope to be of much service, and, though tacitly accepted by many roads, it is customary to arbitrarily cover certain points of difference not touched upon by the M. C. B. Code by a special or temporary agreement.

It will be readily seen that the conditions which confronted the M. C. B. Association in 1896, with reference to Freight Car Interchange were much the same as those apparent at the present time in Passanger Car Interchange, and a similar radical change of front such as took place in connection with the freight rules in 1896 should now be adopted for the government of Passenger Car Interchange.

The Interchange of Passenger Equipment has become much too common a feature of railroad business to admit of any method of handling other than the speediest one susceptible of accurate accounting and, therefore, there is today urgent need of such a code of rules governing this interchange that uniform-

ity and the consequent labor and time saving in accounting for line expenses may prevail; and also on the ground of economy, as it is a fact that while the expense per car per trip is not an apparently excessive amount, yet the number of cars run daily in line service is a large one, and the consequent aggregate expense per month is considerable and worthy of careful accounting.

Passenger Car Interchange has reference only to the handling of passenger cars in Line Service between points on connecting roads at the junction of which inspectors are stationed to supervise such interchange.

It is true in most cases that the force of inspectors at a junction point between two roads is paid jointly by the connecting roads and it is, therefore, fair to presume that each road receives equally good service from them, and further, that when passenger equipment has been inspected by them and allowed to proceed to destination it must be a fact that the condition of same was fully noted, as the instructions usually given inspectors with regard to passenger equipment do not admit of halfway inspection but, on the contrary, they are cautioned to see that every care is given to insure safety to passengers and property and freedom from delays to trains.

I desire to emphasize the fact that the condition of each car, when it has passed joint inspection, is fully known to the joint inspector, and further that the joint inspector has a complete and authoritative record of same.

To follow the movements of a car from a terminal to a connecting line, it is found to be usually the case, that when defects to equipment are discovered by trainmen, or if casualties occur en route, a full report is made to the superintendent of the division. This report, augmenting the record of the car inspector, furnishes a very complete record of the condition of the car, and as such, is of much service in placing responsibility for any and all defects discovered.

As laid down in the M. C. B. Association Passenger Rules on page 71, the breakage of an axle, the cutting of a journal, or a journal of less than 3 1-2 inches in diameter, are defects which are chargeable to the car owner, provided they are defects which develop outside of what is termed unfair usage, such as

collisions or derailments, though responsibility must be accepted by car owner for same.

The breakage of an axle in regular service cannot be considered unfair usage, as such a breakage in many cases cannot be foreseen, and indeed such a breakage is rarely caused by overloading, but by flaws in the material.

A cut journal which has developed at a time when the lubrication has seemed from an inspection standpoint to be in perfect condition, cannot be accounted for fairly as negligence of the delivering company. It is the stereotyped excuse of an inspector that the cause of a hot box was "want of oil," but it is a well known fact that this excuse is many times untrue with reference to passenger equipment.

It is not fair to the delivering company to make it responsible for the results obtained by the brands of waste, oil and journal bearings used by the car owner, neither should the delivering company pay for defects in running gear which develop in the cars of another road within a distance of 200 miles at least.

A car properly lubricated should run to a destination two or three hundred miles distant without care; and as this is known to be true, why should the delivering company assume responsibility for cut journals occurring, perhaps, in a run of fifty or seventy-five miles, granting that car was properly lubricated at the starting point?

As I have stated, it is the custom of some roads to accept the reports of the operating department and the records of the car inspectors as final information in placing responsibility; and from the fact that no other records are available on any road, it would seem that this course was a wiser one than that in use by many roads wherein each defect is made a subject of controversy.

The latter course has the tendency to delay settlements for defects as well as causing much correspondence which is, many times, of no service on account of differences of opinion.

An acceptance of the available records as authority in placing responsibility is a labor saver in many ways, and a proper and rapid accounting for defects is known to produce comparisons of value and other desirable results.

As in Freight Car Interchange, the road making the repairs should be privileged to bill the car owner for those repairs unless there was evidence to indicate that the damages were occasioned by unfair handling on the part of the delivering company.

In the code of rules which should govern Passenger Car Interchange certain expenditures should be prorated against the roads in the line over which the car is run, those items frequently called "wear and tear" expenses as well as the expense of heating, lighting, lubrication of journals and the expense of cleaning.

In a limited agreement now in force the following items are classed as proratable:

Lubricating oil and waste,
Cleaning,
Illuminating oil and gas,
Wicks, chimneys and shades,
Window glass,
Journal bearings,
Brake shoes.

I would add to these items at least, air, steam, and signal hose, always with the understanding that there was no evidence to show that any of these items were broken or lost unfairly.

I would formulate such an agreement as I have referred to as follows:

PREAMBLE.

Expenses in connection with the operation of all passenger equipment may be divided into three classes, as follows;

Line Expenses (proratable against the roads composing the line on mileage basis). Consisting of heating, lighting (including chimneys, wicks, shades, gas bowls and other minor Pintsch apparatus, illuminating oil and gas), lubrication (waste and oil), cleaning, window glass, journal bearings, brake shoes, air, steam and signal hose.

Owners' Defects. Consisting of defects other than proratable items above listed which develop between terminals with no evidence of negligence or unfair usage.

Delivering Company's Defects. Consisting of defects which are shown by existing records to have been occasioned by negligence or unfair usage.

It will be noted that in the above preamble it is first aimed to make the number of proratable expenses as great as is consistent with fairness in order that the roads forming the line might participate in what are truly called wear and tear expenses, and second, that car inspectors' and train records be made full authority for placing responsibility for defects, thereby avoiding much correspondence, which is now needed in some cases in order to dispose of items of minor importance.

I would follow the preceding preamble with a complete list of articles used in repairs with prices for same, and it is the opinion of the writer that a more complete list than is now given in the Freight Rules or the Pullman Rules should be furnished for greater convenience in accounting, and especial attention should be shown to the expense of handling wheels belonging to foreign roads placed under cars for temporary service.

An agreement such as I have outlined is not in any sense complicated and, like *uniformity* in any other line of business, it produces the results which are needed here to a notable degree, which are a full and complete accounting, which in turn furnishes the comparisons necessary to a betterment of the service of all who are concerned in the handling of the equipment.

As I have previously stated, an agreement of this class is needed at the present time to facilitate the business of Passenger Car Interchange and it is my sincere desire that same will be adopted in the near future.

THE PRESIDENT: Now, gentlemen, we have heard this paper read, and if my memory serves me correctly, we have not had a discussion on this subject in this Club for at least a long time. It is no doubt getting to be a fact that it is a coming problem, or I don't know that it is a coming problem, I guess it is a problem that has already come. Therefore, I would be glad to have the thing picked right up and the discussion proceed with all the energy possible. This is particularly a car department

subject. The other was a motive power department subject, and we gradually got the men moving a little; I trust that the car men will now come to our relief.

MR. J. W. MARDEN: Mr. President, I don't know that I have very much tc say on the subject presented to us, but I think that every one who has had anything to do with passenger interchange will appreciate the facts outlined in the able paper just read by Mr. Carr. It is a fact that our passenger interchange rules are incomplete. We not only have our passenger interchange rules as outlined by the M. C. B. Association, but we have passenger interchange rules between the Boston & Maine System and sixteen other roads, known as the "Boston & Maine Agreement." We also have rules governing the interchange of Pullman cars. As I understand it, it is the object of this paper to bring before the Association the neces sity of having more complete passenger interchange rules, that may be adopted by the M. C. B. Association, to include the rules above mentioned, and thus avoid the necessity of three sets of rules, and with that end in view, I will offer the following resolution:

"That a special committee of three members be appointed by the Chair, with full power to formulate a code of rules for the government of passenger car interchange, and with instructions to refer the same to the Arbitration Committee of the M. C. B. Association, with a view of substituting the same for the present code of passenger rules."

(The motion was seconded.)

THE PRESIDENT: I remarked a while ago that there would probably be a motion that should really be classed under new business. I had reference to this. Therefore, I will put this motion and the discussion can follow, and we will vote on it after the discussion has proceeded. It is moved and seconded that a special committee of three members be appointed by the Chair with full power to formulate a code of rules for the government of passenger car interchange, and with instructions to refer the same to the Arbitration Committee of the Master Car Builders' Association, with a view of substituting same for the present code of passenger rules. Remarks are in order, gentlemen.

Mr. Cleaver: Mr. Chairman, I would like to say that I approve of that action, and think it is a wise one. I think it ought to have originated perhaps a little earlier, but if the committee who are appointed stir themselves they may do some good before the next M. C. B. meeting. It is certainly a fact that our interchange rules for passenger equipment need revising. In many cases at the present time they are unintelligible. We don't know what they mean, and we have to use our own judgment. Very often our own judgment leans toward the side of the road that we happen to be working for. There is quite a number of those cases, and when we are revising the rules we ought to clear them up, as all language used should make absolutely plain what is meant.

The President: Any other remarks on the subject, gentlemen?

Mr. J. T. Chamberlain: Mr. President, perhaps this matter of passenger rules is somewhat a hobby of Mr. Carr's. For a number of years back he has been trying all he can to have some sort of a rule formulated that the different roads in line service could live up to, and one that would be complete throughout. I think it was more his constant keeping at it than anything else that resulted in what is known as the New England agreement, or the agreement formulated at the Gilsey House, New York, some five or six years ago. With a few exceptions we have it in operation with all the roads with which we connect, and it has been a very good code from a clerical standpoint. The object at the meeting at the Gilsey House referred to was that materials and prices should be set forth. Mr. Carr has intimated in his paper to the extent of probably fifty to seventy-five articles, mostly used in maintenance of the passenger work. What is now desirable is not only that the material and prices be named in the passenger rules, but the rules themselves should be more plain and more in keeping with the freight rules, which now precede the passenger rules. I think that if a good live committee is appointed (the convention not meeting until about the 21st of June, somewhere about there), a code of rules could be submitted that might either go through in whole or might be adopted in an amended manner, that would carry with it a certainty that the inspectors today have not got. There are

but few articles of material and prices laid down in the present passenger rules. As said by Mr. Marden, and as said by the writer of the paper, Mr. Carr, they are very incomplete. I think that between now and the early part of June, say the first of June, the committee ought to be able to to draw up a set of rules and enumerate all articles and prices for the same, and present it to the Arbitration Committee, as Mr. Marden has suggested in his motion. In fact, I had a motion in my vest pocket to cover that. I didn't know that he had one.

THE PRESIDENT: Any other remarks? The last speaker has just said that we require a good live committee, and I have no doubt that he would make a good chairman, because he would want to have that committee come up to what he thinks it ought to be.

MR. CHAMBERLAIN: I did not want a job.

MR. E. T. MILLER: Mr. President, there is just one thing that I hope that committee will make car owners responsible for. It is my misfortune to ride on certain trains that, if they are on time, get to Boston somewhere about 7 o'clock, and they do not always get in on time, owing to hot boxes. I hope that the committee will make it imperative that car owners shall be responsible for all hot boxes on their own cars, and make the price for renewing the brass and waste the maximum price.

THE PRESIDENT: If there are no further remarks on the subject, we are ready to vote on this motion. I think it is unnecessary to read it again.

(Mr. Marden's motion was adopted.)

THE PRESIDENT: I would appoint as chairman of that committee Mr. J. T. Chamberlain, of the Boston & Maine Road, and as the other members: Mr. A. J. Fries, of the Boston & Albany Road, and Mr. T. W. Adams, of the New Haven Road.

That closes the discussion or the business of the second paper, unless Mr. Carr would like to say something in closing.

MR. F. A. CARR: I don't think I have anything further to say, Mr. President.

THE PRESIDENT: I know of nothing more for this evening, with the exception of one or two announcements. I want to say that, as this is the last meeting of this season, it behooves

us to go away and get so rested that we can come up here next fall and enter the discussion without being called upon by the Chair. I also want to say that the Subject Committee met last evening, and it was a very successful meeting from my point of view. I think the subjects for the next season are to be such as will be very instructive and exceptionally interesting. We have made a particular study to take in all classes of railroad work.

(Adjourned.)

New England Railroad Club

October 11, 1904.

SUBJECT FOR DISCUSSION:

Steel Cars as Adapted for New England Railroads.

Paper by Mr. JOHN F. MacENULTY.

E. L. JANES, SECRETARY, 185 SUMMER STREET, BOSTON, MASS.

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The regular meetings of this Club are held at Pierce Hall, Copley Square, corner of Dartmouth Street and Huntington Avenue, Boston, on second Tuesday of each month, excepting June, July, August and September.

NEW ENGLAND RAILROAD CLUB

Published Monthly, except June, July, August and September,
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E. L. JANES, SECRETARY, 185 SUMMER STREET, BOSTON, MASS.

$1.00 A YEAR. *Boston, October 11, 1904.* 15C. A COPY

A REGULAR MEETING of the New England Railroad Club was held at Pierce Hall, Copley Square, Boston, on Tuesday evening, October 11, 1904, at 8.00 P. M., President W. B. Leach in the chair.

The following members registered:

Adams, T. W.	Field, Wm. W.	Manning, J. P.
Adams, W. H.	Flannery, John J.	Marden, J. W.
Allen, C. Frank	Ford, John M.	Martin, G. W.
Armstrong, C. R.	Fraw, John H.	McCombs, H. W.
Bailey, Chas. A.	Fries, A. J.	Millar, E. T.
Bean, W. G.	Goodwin, C. E.	Murdock, J. C.
Bigelow, Chas. H.	Handy, A. W.	Murray, D.
Brady, J. T.	Hayden, M. E.	Nesdell, F. F.
Brush, G. M.	Hegeman, B. A., Jr.	Olson, G. A.
Carter, T. W.	Hindle, W.	Patterson, S. F.
Chaffee, E. F.	Hunter, D. W.	Philbrick, F. W.
Copp, Chas. E.	Humphreys, James	Post, C. J.
Deane, J. M.	Ingraham, Fred F.	Potter, E. E.
Desoe, C.	Janes, E. L.	Probert, Joseph
Doran, S. P.	Keay, H. O.	Randall, Chas. E.
Doty, Clark	Kelliher, John	Rice, Edmund
Dowdell, Augustus	Leach, W. B.	Richardson, A. H.
Duckering, C.	Lindall, John	Robinson, J. B.
Eddy, F. H.	Lindley, R. M.	Sherburne, Chas. H.
Ewart, John	MacEnulty, J. F.	Smith, C. B.

Smith, Percy C.	Swett, Geo. W.	Webster, George S.
Smith, W. B.	Todd, L. C.	Wetherbee, F.
Sutton, G.	Towle, J. M.	White, A. M.
Sprague, C. E.	Trubee, W. A.	Woodward, C. N.
Swett, G. B.	Twining, Edw. H. B.	

THE PRESIDENT: The gentlemen will please come to order, and I would request that you come forward as far as possible, otherwise you may regret it. There being no objection, the minutes of the previous meeting may stand approved as printed in the May book, which you all should have. Are there any Committees to report?

THE SECRETARY: There are none.

THE PRESIDENT: Any Unfinished Business?

THE SECRETARY: No unfinished business.

THE PRESIDENT: Any New Business? The Secretary will read the names of two gentlemen who have been elected as members of the Club.

THE SECRETARY: Mr. Archibald N. Campbell of the Columbia Refining Company and Mr. E. H. B. Twining, representing the Edward B. Kent Company of New York City.

THE PRESIDENT: Under the head of "New Business" I might say here that, as you are all aware, this is the first meeting of the season of 1904–05. We are desirous of having the most interesting meetings this winter that we have had for a long time, and in order for the Subject Committee to meet with the success that they hope to,—and when I say that I include all the officers of the Club in addition, and it should include each individual member,—it will be necessary for the members to become more interested than they have been in the past, and to participate more freely in the discussions.

We hope to have some very interesting subjects for the meetings, and they are all fairly well arranged for,—so far as designating the subject for the various meetings. I think you will be pleased with them, and when you receive the notices for these meetings, I wish you would give the matter a little thought and come here prepared to have something to say on the subjects,—do it voluntarily, so it will not be necessary for the Chair to call upon the members.

It is very fitting — being the first meeting of the season — that the platform, as you will observe, is beautifully decorated. I think it is the first time in my recollection that we have been so favored as to have such a handsome display of flowers at one of our meetings. I am sure I appreciate it, and you will also, and I may say that we, as a Club, are indebted tonight for this display to the ladies of the Episcopal Convention, who are holding meetings in this hall. A written vote will not be necessary,— just think gratefully of them.

Continuing under the head of "New Business,"— at the Executive Board meeting this evening we were considering the advisability of having another Ladies' Night this winter. We have had two,— one last winter and one the winter before,— and there are a few of us who enjoyed it immensely, and I think many of us did; in fact, I heard an expression of opinion among members that it was a success, that they were pleased, and would be pleased to have another; therefore we are considering it. The hall has been tendered to us for this Ladies' Night, so called, if we desire it. A committee will be appointed a little later for considering the advisability of it, and if so, what to have; and at a near future date we ought to be able to say something more definite,— I bring it up at this time so you can save the few cents necessary to entitle you to admission. I think we got about a $2 supper, entertainment and dance for 50 cents, and last winter we did not have as many of the members buy tickets as we thought should, although we had a good attendance and a good time. Keep it in mind, because we shall want you by-and-by to purchase tickets and come and have another good time.

I am very sorry to be obliged to announce that since our last meeting we have lost one of our members by death,— Mr. F. D. Adams, who was our first president, and who was one of our honorary members. Mr. Adams died in Buffalo about three weeks ago, and we received a very short notice of it; in fact, so short, that the only thing we, as a Club, could do was to show our respect by sending flowers to the funeral, which we did. Most of you remember Mr. Adams very well. Many of the older members had a respect and love for him that will not diminish, even though Mr. Adams has passed

away. Many of the younger members knew him also, though, perhaps, not so well, and yet they were bound to respect him for what he was and what he was to us. A committee has been appointed by the Executive Board to draw up a set of resolutions and an obituary notice fitting to the occasion. This will be done, and it will be printed in the Proceedings, probably, of this meeting. I might say that the Secretary has received the following letter from the family of Mr. Adams, expressing their appreciation of the remembrance which we sent them:

READVILLE, MASS., September 24, 1904.

MR. E. L. JANES,
Secretary New England Railroad Club,
BOSTON, MASS.

DEAR SIR: — I have just returned from Buffalo, where I went to attend the funeral of my father, which occurred there on Sunday, the 18th inst. On behalf of the family, I wish to thank the members of the New England Railroad Club for their sympathy, so beautifully expressed in their floral offering.

My father passed away very peacefully at the last, for which I am very thankful, as he had been a great sufferer; he became unconscious about 1.00 o'clock P. M. on Thursday and died at 1.00 o'clock A. M. Friday.

It is a source of very great pleasure to feel that he was held in such esteem by the members of the Club, which, while he made his home in the vicinity of Boston, was very dear to his heart.

I trust you will kindly express to the Club in some manner my thanks and appreciation for their kindness, and by so doing you will confer a favor on myself and my relatives.

Yours very truly, T. W. ADAMS.

During the summer I received a communication from the chief of the transportation exhibit of the St. Louis Exposition regarding what they desired to term a "Railroad Club Day" at the Fair. It was their desire that the railroad clubs should, if possible, meet there collectively as clubs, and if this were not possible, to meet there as individuals, and enjoy the hospitality of the Transportation Committee or the committee appointed to receive them. We had no meetings at which we could call the attention of members to this or at which we could take any action, and, therefore, the only thing we could do, after we learned the date that this was to take place, was to notify each member of this organization to that effect

and request him, should he be at the Fair at that time, to avail himself of the opportunity to attend this meeting or to make himself known to this committee and receive any hospitality which they might desire to extend to him at that time. This notice was sent out, but further action on our part was impossible. How much good it did I am not prepared to say; but I trust if any member was there at that time and could avail himself of the opportunity that he did so.

Under the appointment of committees I would say that the committee for the consideration of a Ladies' Night has not yet been appointed, but will be by the Chair at an early date. I would say for the information of the members that under the item of appointment of committees, the Chair has this evening appointed on that obituary for Mr. Adams,—Mr. Marden as chairman, Mr. Chamberlain and Mr. Ford.

Has any member anything to bring before the meeting at this time under the head of "New Business"? This Club, gentlemen, belongs to us, you know; it is just as much your Club as mine, and if at any time any member has anything to say that he thinks is for the benefit of the organization or would help him in any way, I trust he will have his little say right here on the floor.

There is just one thing more I would like to speak of—this being the first meeting—and as I have heard, and the Secretary says tonight that he has heard the same thing, members have made the remark that they have come here and it has been their privilege to sit in the back row and listen to what transpires here, and then have gone out without feeling at all acquainted. I am sorry if that is the case; but, gentlemen, if you won't "get busy" of your own accord, I don't know how we can help it any. I would be very glad if any member who does not know me would just come right up here after the meeting is over and tell me his name, shake hands, and we will call "get acquainted," and I will introduce him to all the members I can, and the Secretary and any member of the Executive Committee will do the same. If you don't get acquainted then, do not lay it to the New England Railroad Club or to any of its officers,—it is just as much your fault as ours. I know a good many people here because I am what you

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call "a mixer"; some people are not, but they ought to come down here and make an effort to get acquainted. I told one man I would introduce him to ten members, and if in three meetings more he did not know fifty it was "up to him."

If no member has anything to say, we will pass to the subject of the evening, which is "Steel Cars as Adapted for New England Railroads,"— a paper by Mr. John F. MacEnulty of the Pressed Steel Car Company.

I have the pleasure of introducing Mr. MacEnulty.

STEEL CARS AS ADAPTED FOR NEW ENGLAND RAILWAYS.

Steel cars have been made, in years past, the subject of many exhaustive papers treating upon the advisability of use, best type of construction and method and cost of repair,— which papers have, no doubt, been read and digested by the majority of the gentlemen present. I shall, therefore, only treat of the matters as they pertain to the question before us.

Metal cars in the United States, while comparatively of a late origin, the first of any quantity being built in 1897, are yet older than is generally known. Experiments have been made by men whom we might assume were in advance of their time, and today we are sometimes surprised to find in an out-of-the-way corner a car of some queer design that probably made a great stir in its own small world when it was new, but which in the busy whirl of modern existence had long since been forgotten and abandoned, except by those unfortunates whose duty it is to keep it in repair. These types of cars are often pointed to by those not favoring steel construction as an example of the unfortunate end of the modern product. A short time ago it was my good fortune to come across some all-metal box cars in a railroad yard that, I learned subsequently, had been in service about twenty-five years and are now doing duty as ash cars. These cars bear about as much resemblance to the modern steel car as an old wood burner does to our latest type Mogul locomotive, and were, no doubt, of a weak design, even for the time in which they were constructed; and, therefore, using them as an

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argument against our modern designs would be manifestly unfair.

The bugaboo of corrosion also has many adherents, and there have been enough papers and miscellaneous literature printed treating on the proper preservatives, methods, etc., to paper all the cars in New England. In fact, some extreme types of arguers on the opposite side of the question have inferred that a car of steel construction would, in the course of time, by the action of weather, etc., entirely disintegrate. We car builders think we build a pretty good car, but the only vehicle on record that was constructed so as to have one part last equally as long as the other, is the famous "one hoss shay," built by Deacon Brown, and close scrutiny fails to locate his name on the roster of any steel car building concern. It is safe to assume, therefore, that one portion of a car will fail before the remainder; what that portion is will be due to the individual service of the car in question and to the ability and forethought of the designer. I have only to say that the first cars built by us in 1897 have been running in the coal and ore trade continuously, and do not show evidence of deterioration from any cause whatsoever. We have records of cars in service on the Eastern Railway of France built in 1869, showing in twenty-eight years of service a loss of only 6% by corrosion.

The claim that the chemical action of coal from a "wet" mine will eat through a plate in a short time has not as yet been proved by actual results. Take, for example, the locomotive tenders; they represent a condition that a car would never meet, yet there is no movement that I am aware of to substitute a wooden lining in the coal hoppers. For the sake of argument, we will suppose that a car has been left on a side track for a few years, loaded with soft coal and exposed to all inclement weather. This, of course, is practically an impossible condition in these days of the *per diem* system; but, I say, supposing that this happened and this car had gotten in such condition as to need repair. Is it not reasonable to believe that the parts affected could be repaired or cut out and replaced just as easily and as cheaply as similar parts could be replaced on a wooden car? I know from actual

experience that it is much easier to cut out soft-steel rivets with a cutter and a maul than it is to saw through a soggy piece of timber with nails in it.

One of the largest railroad systems in the country, operating some 20,000 or 30,000 steel cars, determined, by actual experiment, that the steel entering into the construction of their cars lost in four years about 1-200 of an inch by corrosion. As a result this system is not repainting any more of their steel equipment. From an artistic point of view it cannot be said that this idea is an enthusiastic success, as a train of unpainted cars after several years' use would present a color scheme something akin to a battered tin dinner pail; but when the results show on the right side of the balance sheet, the scenic properties of equipment are not usually considered.

In New England the tendency has been, with a few exceptions, to adhere to an all-wood construction. The principal reason for this is, so far as I can learn, not prejudice, but a deep-rooted conviction — its source emanating from where I know not — that steel construction is desirable only when used in connection with a high-capacity car. The service on a majority of the roads in this section, not usually demanding a box car of over 60,000 pounds capacity, steel construction, has, to a great extent, been considered unnecessary.

The cost of a 60,000 pounds capacity wooden car, not including a flat car or a car designed for special purposes, is from $18 to $30 per ton of carrying capacity. This price, of course, is governed by the following conditions: First, the type,— a box car costing more than a gondola; second, the specialties used, including trucks; third, the ideas and ability of the man designing the car. A 60,000 pounds capacity box car — the same specialties and trucks with steel underframe — will cost from $2 to $4 more per ton carrying capacity, or from $60 to $125 per car.

I shall show later by comparative figures, based upon the net earnings throughout their assumed life, that this increase in first cost is advisable.

The reasons for building small-capacity box cars should not, in this section, apply to gondolas and flats. The lading in

cars of this type is of such a character that a higher capacity car made of steel could be used to great advantage. You can see every day in freight trains gondola cars carrying coal, stone, lumber, iron and steel products, seemingly loaded above their capacity and showing evidences thereby of very rough usage. These cars, too, are not old, many of them having been built in the last five or six years. I have seen flat cars around quarries and lumber regions with a load on them that if the original designer of the cars in question were to see his hair would stand on end. The fact that these cars hold up as they do shows the excellence of design and great care of maintenance on the part of the roads running and operating them, but the cost of this maintenance could be decreased by use of steel construction to an extent extremely gratifying to the man higher up.

One point in favor of steel construction in a box car is this: the underframe being rigid, the posts and braces are called upon to withstand only the shocks from horizontal strains of the load. A wooden underframe is continually settling, and the superstructure is thus brought in to assist the sills in supporting the vertical load. This undue usage soon makes evident its severity, and bulging sides and ends and leaky roofs are the natural result. By the use of the rigid steel underframe there is quite a saving on the flange wear of the wheels. Wood construction, as we all know, is as a general rule made up from lumber that is not thoroughly seasoned. It may be bought as seasoned timber, but in these days of cheap prices and quick delivery it is very rare that it is up to the specification desired. As a result from natural shrinkage a wooden underframe will in the course of time ride flat on the truck side bearings. This causes an enormous friction on wheel flanges with correspondingly disastrous results. A properly constructed steel frame will hold up under any conditions and allow free movement of trucks. The influence of this condition is shown also in draw-bar pull of locomotives. It has been determined by two of the largest railroad systems in the country that the draw-bar pull required to move a ton of freight in a properly constructed car of 100,000 pounds capacity is 24% less than

required to move the same amount in an average wood car of 60,000 pounds capacity. The locomotive expense to be affected by this would amount to 15 cents per mile. With a mileage that represents 480 train or locomotive miles at 15 cents per mile the total cost per year would be $72. If the same load is moved in a steel car this saving of 24% would amount to $17.28 per year. This percentage would, of course, not be so great comparing steel and wood cars of same capacity, but it can be readily seen that there would be a marked difference. The constant increase of motive power and the heavier tonnage being hauled per train is fast bringing about a condition that will necessitate the introduction of steel in the underframe of every new car built. Cars are constantly being hauled in trains of 2,000 tons or over, and they are subjected to severe buffing strains from the shocks of heavy high-capacity cars shifted against them in the classification yards. To construct a wooden frame to successfully meet these conditions and withstand the increasing rough usage would necessitate an outlay of first cost that would be useless, when we consider the comparative small increase of outlay necessary for a car of steel construction.

Reports from different large systems place the average cost of repairs to wooden cars anywhere from $35 to $80 per car per year,— this last figure being from a system that uses over 100,000 wooden cars over a large territory. The average cost of repairs to steel cars and cars of steel underframe ranges from $9 to $15, and that, too, on cars having been in service six or seven years.

The comparative cost of maintenance of steel and wooden cars has been carefully worked out by Mr. C. A. Lindstrom, formerly with Pennsylvania Railroad and later with the Chicago & Alton Railroad. He is a recognized authority on car building and maintenance, his experience having extended over a long period of years. The figures submitted in the following table are based upon actual results obtained from roads using steel and wooden cars. The life of a wooden car has been put at fifteen years. There are, of course, instances where wooden cars have been in service for a longer time, but I do not think anyone will question this figure as a fair

average for a car in continual service. The average life of a steel car is assumed at twenty-five years. None of our modern cars are old enough to as yet accurately determine their life, and from the behavior of those first built there are no signs of wear that we could accurately figure upon. Basing our estimate on cars in service abroad, we believe that twenty-five years is a conservative figure. At the end of the fifteen-year period of the wooden car the cost, earning power, depreciation, etc., of a second wooden car has been introduced in order to equalize the time represented by the longer life of the steel underframe car,—the cost of the second car being taken from the sum earned by the first car at the end of fifteen years, and the balance of the money being carried forward with a credit of compound interest at the rate of 5% per annum. While these figures are based upon an 80,000 pounds capacity car, the proportionate results for other capacities are similar.

It has been calculated (see report to International Railway Congress Bulletin No. 5) that to haul additional weight of an 80,000 pounds capacity car costs $23.10 per year. This can be paid for by hauling 7 tons 857 miles. Increase in cost for hauling a 100,000 pounds capacity car at the same proportion can be paid for by hauling 7 tons 1,000 miles. A steel underframe for an 80,000 pounds capacity car adds to first cost approximately from $70 to $150 and for a car of 100,000 pounds capacity about $175. It can, therefore, be assumed that as this is practically the only additional cost, the saving in repairs would pay for the increase in first cost in a short time, making a desirable interest on the first investment. To this, of course, can be added the additional earnings due to loads exceeding the capacity of a 60,000 pounds car. It has been recognized by some of the larger roads of the country that they will get lading of over 60,000 pounds in a box car often enough to pay, at this rate, for the hauling of the additional weight and realize a comfortable profit besides, and I do not doubt that this condition would be made manifest in New England by actual trial.

As regards repairs to steel cars, the first thought of the average wooden-car man — when he strikes a lot of steel cars

Statement showing comparative earning value of Stee

Class.	Framing	Purchase Price	
	Steel Under Frame	$730	Earnings at $990.00 per annum for 1st 5 years plus " 961.00 " " " 2d " " 954.00 " " " 3d " " 948.00 " " " 4th " " 940.00 " " " 5th " Less:—Depreciation of value of car at 4 per cent. p Interest on purchase price of car at 5 per c Cost of repairs and renewals at $15.00 per annum f " " " 18.00 " " " " " " 21.60 " " " " " " 25.92 " " " " " " 31.10 " " " Interest on cost of repairs and renewals at 5 per cent Credit by scrap value of car .... Net charge against car........................ ..... Net earnings.. Earnings per $1.00 of purchase cost of car.......... Percentage of earnings per $1.00 invested in purchas compared with wood-framed cars................
	Wood Under Frame 1st Car	$660	Earnings $960.00 per annum for 1st 5 years, plus 5 p " 864.00 " " " 2d " " 826.00 " " " 3d " Less:— Depreciation of value of car at 6 per cent. per annu Interest on purchase price of car at 5 per cent. per Cost of repairs and renewals at $35.00 per annum for " " " 57.50 " " " " " " 80.00 " " " Interest on cost of repairs and renewals at 5 per cent. Credit by scrap value of car .... Net charge against car .... Net earnings.................. .... Earnings per $1.00 of purchase cost of car............ Percentage of earnings per $1.00 invested in purchas compared with Steel Underframe..................
	Wood Under Frame 2d car	$660	Earnings 1st car at end of 15 years less cost of 2d car interest.. Earnings at $960.00 per annum for 1st 5 years plus 5 p " 864.00 " " " 2d " " Less:— Depreciation of value of car at 6 per cent. per an Interest on purchase price of car at 5 per cent. p Cost of repairs and renewals at $35.00 per annum for " " " 57.50 " " " Interest on cost of repairs and renewals at 5 per cent Credit by scrap value of car .... Net charge against 2d car .... Net earnings of 2d car, plus earnings of cash from 1st Earnings per $1.00 of purchase cost of both cars.... Percentage of earnings per $1.00 invested in purchas wooden under-framed cars as compared with st frame car........ ....

rs. Wood Under-framed 80,000 lbs. Capacity Box Cars.

	EARNINGS				
	AT END OF 5 YEARS	AT END OF 10 YEARS	AT END OF 15 YEARS	AT END OF 20 YEARS	AT END OF 25 YEARS
r cent. interest...	$5,470.85				
"		$12,291.81			
"			$20,959.25		
"				$31,988.18	
"					$46,019.98
annum..........	129.71	235.46	321.69	392.00	421.50
. per annum......	201.67	459.06	787.55	1,206.90	1,540.32
st 5 years........	75.00				
d "		165.00			
l "			273.00		
h "				402.60	
h "					557.50
er annum........	4.12	6.11	8.79	12.41	17.27
Total......	410.50	865.63	1,391.03	2,013.91	2,536.59
....	189.00	189.00	189.00	189.00	189.00
....	221.50	676.63	1,202.03	1,824.91	2,347.59
....	5,248.85	11,615.18	19,755.22	30,163.27	43,672.39
....	7.19	15.91	27.06	41.31	59.82
ost of car as .... INCREASE			$8\frac{1}{10}\%$		$118\frac{5}{10}\%$
cent. interest....	$5,304.60				
"		$11,441.38			
"			$18,340.35		
....	168.31	291.83	382.48		
num............	182.34	415.07	712.09		
t 5 years	175.00				
l "		462.50			
d "			862.50		
er annum........	9.66	18.55	29.89		
Total......	535.31	1,187.95	1,986.96		
....	158.48	158.48	158.48		
....	376.83	929.47	1,828.48		
....	4,927.77	10,511.91	16,511.87		
....	7.46	15.92	25.01		
ost of car as ....DECREASE			$7\frac{6}{10}\%$		
; 5 per cent.					
....			$15,851.87	$20,231.45	$25,821.30
cent. interest...				5,304.60	
"					11,441.38
Total......				25,536.05	37,262.68
m				168.31	291.83
r annum.........				182.34	415.07
t 5 years				175.00	
l "					462.50
er annum........				9.66	18.55
Total......				535.31	1,187.95
....				158.48	158.48
....				376.83	1,029.47
ar				25,159.22	36,233.21
....				19.04	27.37
cost of two steel under- ....DECREASE					$54\frac{2}{10}\%$

Average capacity of wooden cars . .		25 tons
Total capacity of all cars		37,500,000 tons
Average mileage per year of car loaded .		3,500 miles
Average mileage per year of car empty .		3,500 miles
Assumed average gross earnings of 1 ton per mile		$ .008
Assumed average cost carrying 1 ton per mile		.003
Yearly income from above gross earnings		1,050,000,000.000
Yearly cost of hauling ladings . . .	$394,000,000	
Yearly cost of hauling all dead weights . .	441,000,000	
		835,000,000.000
Total yearly profit from all wooden cars . .		$215,000,000.000

If the above-mentioned lading of 37,500,000 tons, representing the entire freight business of the United States in that year, was concentrated in large capacity light-weight steel cars, we find that the dead weight would be cut down from 21,000,000 tons to 14,000,000 tons, representing the hauling saving expense of $147,000,000.

The above is merely intended for comparative purposes, and such a Utopian arrangement will probably never be arrived at. Depending upon the locality the carrying capacities vary greatly. Reduced to local conditions, however, the comparative results are approximately the same, with a few less ciphers in the totals.

As to the merits of one type of construction over another, I will not discuss. Any gentleman here that is interested will only need to express in public his intention of buying some cars, and he would, no doubt, have it proven to the entire satisfaction of his informers that every design of car gotten up was absolutely the best and the only one for his use.

The President: You have listened to the paper as read by Mr. MacEnulty on steel cars, and, as there are quite a few car men here tonight, I trust that they will avail themselves of the opportunity to ask Mr. MacEnulty any questions or have

something to say on one side of the question or the other, as they may desire. We are ready to listen to any such now who have it in their minds to speak.

Mr. Chamberlain, as you are sitting in the front row, we would be very glad to hear from you. Undoubtedly you have your views, which the members present would be glad to hear expressed.

Mr. J. T. Chamberlain: I have listened with much pleasure to the paper just read on the subject of steel cars for New England. Situated as I am, and as I have been almost during my railroad life, I cannot say that I am convinced by the paper that the steel car as a whole is a necessity at the present time in New England. I am willing to admit that if I were connected with a road like the Lehigh Valley, P. R.R., New York Central, or an industrial concern like the Joliet Steel Works, or a railroad or concern of that general character, which took their cars direct to the ore or coal fields and brought back 80,000, 90,000 or 100,000 pounds, the question of economy would very likely be much different.

I may misunderstand the reader of the paper where he places, if I recollect rightly, and he can correct me if I am wrong, the life of the wooden car at about fifteen years, and the life of the steel car at about twenty-five. Under certain circumstances that might be correct. I know of railroads whose traffic is heavier than the one I am connected with, who eight or ten years ago on general principles destroyed the 40,000 pounds capacity cars, for the reason that what they called light weight capacity cars was not economy, and in making this reference I include all roads, or almost all, east of the Hudson River.

It is true that the practice of steel in underframing is rapidly gaining headway, but fifteen years, from my experience, is not the life of a good wooden car. It may be true, and probably is, that the repairs to the wooden car, as far as its underframing is concerned, are made with more frequency than would be the case of the present steel underframing. In taking the life of the wooden car, also, it may be possible that to a considerable degree it might be compared with the boy's jack-knife—he first lost the blades, and then got a new handle.

But the car remains about the same, maintained at a not particularly high cost. We have many cars running today of 40,000 pounds capacity, having journals 3 3-4 x 7, and if my memory serves me right this journal was adopted by the M. C. B. Association, or at least first brought forth in convention about the year 1873—that is a trifle over thirty years. Do not misunderstand me, however, that all cars having that size journal were built as early as that period, but I do know that the Boston & Albany R.R., for instance, commenced on that standard certainly not later than 1875, and I presume this road still has many of them in existence.

Referring to the steel car as pertains to general merchandise in the box car shape, it is somewhat a question in my mind as to the practicability of its use for all classes of merchandise, which thought carries me back quite a few years; probably longer than I would care to acknowledge, but somewhere in the late 60's, when the reader of the paper was wearing short dresses, the New York Central R.R. built for the Buffalo and New York grain service a number of thousand of box cars. These cars were not of steel but of iron. They had run them but a few years when, if my memory serves me right, they were obliged to abandon them entirely as far as pertained to that traffic and use them for other merchandise. The trouble was of the great liability of the grain or material of that character to sweat, and I have been led to believe in conversation that the same fear now exists in connection with an all-steel car for grain service. The New York Central iron car spoken of did not have any inside lining, if I remember correctly. I believe that they afterwards put a lining as far up as the girt line, but the car was not a success, even after their experiments, for this service. I think it is but fair to say, however, that the cars did good service with all classes of freight except that above mentioned, and they were finally destroyed because of their not being of sufficient size to meet the increased business, my memory being they were about twenty-eight feet long.

Now, I desire to have the writer of the paper to understand that I am not, in the phrase of the street, "knocking" the steel car. I am merely taking the position from my standpoint, viz.: From the experience that I have had on the road I am

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connected with the all-steel car for general merchandise purposes is not at this time a necessity.

I have been a great believer, and I am today, in a certain type of steel truck, and I am very much of the opinion that we are coming very soon to steel underframing, but I think a road like the Boston & Maine, and I might include the Maine Central, Central Vermont, Rutland and such roads in the eastern part of the country, not including the Canadian Pacific, there is no necessity for a car having a carrying capacity for general merchandise of upwards of 60,000 pounds, which would carry with it a 4 1-4 x 8 journal.

Now, that statement seems to be entirely at variance with the general practice throughout the country the last few years, from the fact that there have been many cars built for general merchandise traffic with a carrying capacity of 80,000 and 100,000 pounds, respectively. It is true that the more tonnage you can get into a car if you have it to haul, the more economical it is from a number of standpoints, and especially is it true from the fact that it shortens up the train. I had intended before this meeting to find out what our average load per car was, but have neglected to do so, but I question very much, even taking the Boston & Albany R.R., which has a considerable through service, whether the average load per car, both through and local freight, will exceed twelve tons. My figures may be low, and it is possible it might come up to fifteen tons, in which case I would be surprised; in fact, I would be surprised if they reached what I consider the high figure of twelve tons per load. I remember that some time prior to 1888, in which year I left the Boston & Albany road, I had occasion to ascertain the average load on all loaded cars arriving at and leaving Boston, including not only the through but local service, and my old friend Jim Gay, who was then freight agent at Boston, made up the figures for me, and they lacked a little over seven tons.

Now, it is true that a railroad going to the mines, either coal or iron, and bringing back 80,000 or 100,000 pounds of that material, if their roadbed and bridges are of sufficient strength, which, of course, they would be, it would be economy to manufacture cars for that traffic, but when these same cars are to

be used for general merchandise the major portion of the year, it is a question in my mind whether or not it would be economy to construct a heavier car, bearing in mind, of course, that I am right in my estimation that the average load per loaded car is what I believe it to be — less than twelve tons.

I think I had better stop now.

THE PRESIDENT: Has any other gentleman anything to say on this subject? Mr. Adams, won't you give us a few remarks and your opinion or experience on the question?

MR. T. W. ADAMS: Mr. President, I do not know that I can add anything to the remarks that Mr. Chamberlain has made. I am inclined to agree with him in most everything that he has said. The road that I am connected with at present has a number of steel underframe cars and a considerable number of all-steel flat cars; we have quite a number of 80,000-pound steel flat cars which are giving us at the present time comparatively little trouble—I might say no trouble whatever. Of course, we haven't had these cars in service long enough to demonstrate without a doubt that they are the perfect car.

Our box cars with steel underframing that are in service are doing well; we have, of course, some repairs to make on them, but in comparison with the repairs that we give to our wooden cars, I rather think that the steel underframe compares very favorably. Our ordinary car repairers do what necessary work there is to be done on them — in fact, the men who repair the steel part of our cars are paid rather less than the average wood workman; some of the men we employ in that capacity are even taken from our yard, our laboring force. In a very short time they become expert enough to make those repairs very readily, and with the forges, oil-heaters, pneumatic hammers, etc., we use for that purpose, the men get along very nicely.

So far as the average load goes I think Mr. Chamberlain's figures are rather high if anything; I think the average load on our system would not reach 15 tons. Of course I don't make that statement from any figures, I simply make it from such observation as I have had the opportunity to make.

As I said before, our experience with steel underframed cars has not been of such extent as to warrant my endorsing them

as the coming car; I am not prepared to say whether they are or not. I don't know as I could say anything more, Mr. President, in regard to it.

MR. CHAMBERLAIN: Just one word. I forget now whether I did express myself, but I think I did, relative to the matter of steel underframing. I am certainly a believer, when talking about general merchandise, in what is known as the wooden car.

I think I did express myself, and if I did not I want to be clearly understood that I think that steel underframing is an important matter, and while I am not prepared to say that, situated as I am, we are at the present time prepared for it, or at least where I think it is absolutely necessary, yet I am much more of a believer in steel underframing than I am in the all-steel car, and my object in rising at the present time is to say that I do not want to be considered as an absolute opponent of the steel car in any part thereof.

THE PRESIDENT: If I remember correctly, your expression of opinion in your previous remarks was to that effect. I would like to hear from the next gentleman who is prepared to say a little something. Mr. Miller looks as though he was about to stand on his feet.

MR. E. T. MILLER: I have listened with a good deal of interest to the remarks of Mr. MacEnulty, also Mr. Chamberlain and Mr. Adams. I cannot agree with those gentlemen on the life of their wooden car, from the fact that I looked at some cars today that we built less than ten years ago, and they are practically ready for extensive repairs.

It might have been possible twenty-five or thirty years ago to have wooden cars built to last for thirty years, but today I feel confident that you cannot get a car built in the United States or Canada that in ten years from today will be good for anything without a great deal of repairs to it, and the reason is we are cutting the tree down one day and running it out with a coat of paint on it practically the next week. Our timber is green, of poorer quality, and the cars are not getting the same care that they did years ago.

The same thing may be applied to the steel car, but if that is a proper way to run the railroad it must be so. I believe that a steel car, if it gets any care at all, will last well, much

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better than the present timber that we are getting, which is of inferior quality because it is not old growth, and consequently will rot much quicker. Put steel cars on the road without any attention at all, and let them rust out for lack of paint, they won't last very long; but if they get any reasonable attention they will give good service.

I was glad sometime ago to use some steel for the construction of cars, and don't know what I could have done with wood to carry the same load, because I don't believe I could have got it together. I looked, about two weeks ago, at some trucks which were all steel and as near as I can find out they have been in use about thirteen years. In comparison with those trucks I looked at some diamond trucks, which were part wood and part iron, I looked up the record of these trucks, and in about the same number of years had been built over three times, that is, the bolster part has now the third stick of timber, which meant that the cost of the truck was pretty near twice what it originally was, that is, in the replacing of the bolster.

I believe there is a time coming, and not very far distant, when even though our tonnage is light we will have to use steel under-frames, because lumber is getting scarce and poorer. There is one thing for certain, that whether the railroads in the eastern sections of the United States use steel cars, or build steel cars of their own, they will have to educate themselves to the repairs necessary for the cars coming to them. It appears to me that the attention has not been given to repairs on steel cars that should have been.

THE PRESIDENT: Professor Allen, aren't you prepared to say a few words, as an entirely neutral party, who looks at it in a more scientific way, perhaps?

PROFESSOR C. FRANK ALLEN: Car construction is not distinctly a part of civil engineering, which is my line of work, nor am I especially familiar with steel cars, and perhaps not sufficiently familiar with wooden cars; and yet I have given some attention to the study of car construction. Though I do not feel very competent to say much on the subject here among those engaged in building cars, there are one or two points that occur to me which it may be worth while to bring out.

Apparently, so far as New England is concerned, the question is in part what size of car should be used, and if the loads are on the average smaller here, or if most of the loads are smaller, it appears that there may be some disadvantage in having larger cars made. I am not sufficiently familiar with the methods of operating to know to how great an extent it may be possible to use heavier cars for what you might call "through service," and lighter cars for "local service." Of course that cannot be done completely. Whether it can be done even by careful operating to a larger extent than is done now, I am not altogether clear. I understand, of course, that on branch lines, of which there are many in New England, there is likely to be a small business and it is necessary to carry a good many very small loads, and it is not economical to carry them in the big cars; sometimes, I suppose, it is economical to reload rather than carry a part of a load in the big car.

The paper presented by the speaker of the evening has been very interesting to me. There are many points he has brought out which have been of special interest, as I look at matters of that sort. His analysis of the economy of the two styles of car is very interesting, and will be especially so when the whole story is before us in print. I believe that discussions of this sort are very valuable to railroad men, taking into account, as they do, the value of interest and service as well as of first cost.

The whole matter of train resistance is very interesting to me, and that was touched upon by the speaker of the evening. If the load can be put in fewer cars there is, of course, less atmospheric resistance, and there is a gain made. If your trucks are in good shape the resistance is less, and there is a gain made. Following up what Mr. Miller has said in relation to diamond trucks and steel trucks, I have no doubt that a more severe indictment of the diamond truck can be made on a basis that he has not touched upon. If a diamond truck has to be taken out and renewed frequently, there is very little doubt that for some time before it is renewed it is sufficiently out of square so that it becomes very hard to haul, and the cost of the heavy hauling should be taken into account. This

is a point that has of late interested me quite a little. It is common to talk about rating locomotives at so many tons; that means for any car so many tons whether these are put into one car, brand new, square and fine in every way; or so many tons put into some old type of car that pulls about three times as hard; in tonnage rating as practised it is so many tons still, the same in one case as the other. I suppose it is too early for railroads to come to the point where they can reject a car because it simply pulls too hard, and it certainly is hard to determine in the case of any single car that it does pull hard; and yet in the case of a road that is hauling a car several thousand miles, it might be possible to make some test, like running down hill, to ascertain whether it is an easy running car or pulls two or three times as hard it ought to pull, and therefore ought to be turned out of service. It might be possible to do this in gravity sorting yards. It would then be in order to have the interchange rules apply to the hard-pulling car as they do to one that has other serious defects.

Apparently I have not said much that is in point with the rest of the discussion, but have simply called attention to one or two things that have occurred to me, and have indicated, perhaps, somewhat how my line of thought is likely to run in such matters. I find that in discussing almost all railroad questions the point that presents itself to me directly is, what effect, if any, is this going to have on the number of tons you can pull behind your engine; so that when that matter was touched upon in the paper I was glad to hear it; when you come to look at matters in that way, it is astonishing to see how many different things bear on the length of your train, and if you can get one more car on the train, with the same locomotive, it costs very little to haul it; and we all know the gain is very large, provided, of course, you do not make your train so heavy that you cannot successfully operate it.

THE PRESIDENT: In connection with what the Professor has just said in regard to the increased tonnage hauled by locomotives, I had that demonstrated to me the other day rather forcibly, which as I think of it now, and as I considered it then, was a card in favor of the steel car for the particular line

of service that I saw; and as one of the speakers during the discussion has said that if he were so situated as to have a lot of cars that went to the mines and received their load, and went to a certain place and discharged it, perhaps that would be a very good argument in favor of the steel car.

I was out to Ashtabula the other day, and I saw the ore vessels in at the dock. I saw the ore cars lined up all along through the yard, and I was informed that they took the iron ore and filled the cars full—took all they could haul on a train, and carted them off down into the Pittsburg district somewhere, left their load, and reloaded with coal at the mine, and brought them back and put it in the steamers and forwarded it up the Lakes.

Now I don't believe they could haul the tonnage behind an engine in wooden cars that it would be possible to haul with the steel car. They told me out there they came in a little while previous with a trial train of a hundred cars, together with a caboose, and the cars were all of a 100,000 pounds capacity, loaded, and drawn by one engine; and I was told that there was something like 6,000 tons hauled. They were all steel cars, and I don't believe we have any engine that could have hauled that load had they been in wooden cars, particularly had the cars been in that kind of service any length of time; and it demonstrated to me that the 100,000 pound capacity of steel car would very soon earn its money if it were left right in that service going back and forth.

Perhaps Mr. Woodward would like to say something here tonight from the operating side of the question. He may have in mind some little thing that will be of interest to us.

MR. C. N. WOODWARD: I don't know as I have anything that would be particularly interesting.

I think that some of these wooden cars have had shorter life since the steel cars came into operation; the air-brake applied instantly has shortened some of their lives considerably.

There is a good deal in what Mr. Chamberlain says, I believe in not being able to get a full load on the cars as an average. The New Haven road, with which I am connected, does quite a good deal of through business, and, of course, in their coal

and grain business there is no trouble about getting a big average tonnage. Those cars are sent back largely with a very light load, and a good many times with no load at all, simply to get them back to the West, where they are to be reloaded again.

I think it would be very difficult to try and separate equipment by having a light carrying capacity for local business and heavy for through. The business varies a great deal, and there are times when we have to use a good many cars in one particular line of business, and then again we may want them in another line.

There is a great deal that can be said in favor of increasing the tonnage by getting a large load in the cars; much more freight can be hauled if the cars are heavily loaded.

MR. CHAMBERLAIN: I still wish to be right in this matter, and Mr. Woodward in his remarks has dropped a word or two about empty cars. I desire it to be borne in mind that it is my opinion that the average load per car on roads in New England will not exceed twelve tons, and it would rather surprise me if it went to that figure, and in making up that average it is to be understood that empty cars should not be figured in the estimate at all.

I do not suppose Mr. Woodward understood my remarks as intending to figure in empties as well as loaded, but for fear there should be any misunderstanding about it, I wish to place myself right.

THE PRESIDENT: I am going to call upon a gentleman now who is not one of our members, but who comes here from an adjoining state occasionally, when we have a car department subject, and if he will speak I shall be very glad to hear from him. I will call upon Mr. Doran.

MR. J. F. DORAN: I do not know that I can say very much on the subject that has been discussed this evening, as my experience with steel cars and underframing has been limited; at the same time I am fully in accordance with Mr. Chamberlain and Mr. Adam's remarks regarding the subject, but so far as wooden cars are concerned I do not agree with Mr. Miller as to the average life of the same. We have some wooden coal cars of 80,000 lbs. capacity that were constructed

in 1898, and practically speaking they are just as good today as when built. As to cars not lasting over ten years, it may be due to the fact they have not received proper attention after being built and placed in service. We all concede that the timber in them is more or less green when first constructed, and if they were taken out of service at the expiration of three months and tightened up, they would last much longer and give more satisfactory results. With the steel cars in service it is much the same. If not cared for, in time they will become more or less shaky. There are quite a number of them in transit over our line and from personal observation I have noticed that the underframing and draft timbers were quite loose, and in some of them the end sills more or less damaged where stacks had been used for switching purposes. As to repairs of steel cars we have never made any, those being damaged on our line having been returned to owners for the same.

THE PRESIDENT: You have just said that you have broken up some of them. Can you give us your opinion as to how they stand up in a wreck, and your opinion of the expense they might be to the railroad after going through a wreck.

MR. J. F. DORAN: Steel underframing, I think, is a step in the proper direction, and it seems to me could be improved upon considerably, giving much better results.

THE PRESIDENT: Will you say something, Mr. Hunter, on this subject? You are interested in cars.

MR. D. W. HUNTER: I don't know that I can say much to you tonight about car construction, I am not in that business just now, but to my way of thinking it is not a question of average loads carried. The car builder has to design and be prepared to carry the maximum, and sometimes more than the maximum load, and should design his car accordingly; it then becomes a question of practicability as to the best manner and best materials to use, both as a matter of economy and good practice.

Now I believe that so far as the construction of flat cars, coal cars, or any other class of cars used for carrying merchandise open to the weather is concerned, we make no mistake in using steel construction throughout. But as Mr. Chamberlain

has said, we are running into the same old trouble that the New York Central found, when we build the housed part of the car of metal, and use it for the carrying of grain and similar merchandise,—weather conditions are against its use.

We all know that wood is a poor conductor and absorbent of heat or cold, and that metal of all kinds is a very good conductor and transmitter of both; it would not seem feasible to build a metal bodied car for a refrigerator car in summer time, although it might be all right for use in winter time.

I think this is one of the points that the writer of the paper read tonight will find difficulty in getting around, if it is the intention to design a box or similar car of all-metal construction. As Mr. Chamberlain has said, you cannot carry that class of merchandise in a metal housed car on account of atmospheric conditions in connection with the metal, and its consequent effect on the grain inside. I don't know as I have anything further to say.

THE PRESIDENT: Now, just because I have been calling these gentlemen's names, and asking them as individuals to enter into this discussion, I do not want any one here to feel slighted if I have not called upon him, because there may be members here who are in a position to talk to us. If there are, and they feel inclined, I trust they will consider themselves as particularly invited to speak this evening.

MR. ADAMS: Mr. President, if there are any more gentlemen going to speak on this subject, will you kindly request them to face the audience? I know it is not customary, but if you will waive the formality of addressing the Chairman, we would enjoy it more, as some of us did not hear a word that Mr. Woodward said.

THE PRESIDENT: When I opened this meeting I asked the gentlemen to come down front, and I asked them three times, and I said that if they did not come down front they would be sorry.

MR. ADAMS: We *are* sorry.

THE PRESIDENT: It is very hard to hear in this hall, particularly the way we are facing tonight, and I knew that someone here would be disappointed. I have been disappointed myself when sitting down there, and that is why I particularly asked

the gentlemen to come up front. If there are any more speakers I will ask them to face the audience.

Mr. Adams: I will take my medicine now, and do better in the future.

The President: I will ask Mr. Bigelow. Can you tell us anything about the elevated end of it? — and don't forget to face the gentlemen.

Mr. Bigelow: I don't think I can say very much on the subject of steel cars tonight.

The President: Is there any other gentleman?

Mr. J. P. Manning: Referring to the matter of the duration of wooden cars. At one time I kept the car record on one of the New England railroads, and the average age was very much greater than Mr. Miller's estimate. It was upwards of fifteen years and many were running and giving good service at twenty. These cars were small, and when in need of general repairs were destroyed on that account, but the records showed beyond a doubt that a well-built wooden car would last more than fifteen years.

Mr. Miller: I want to make myself clear on the age of the wooden car. It is not my belief, and I didn't wish to convey the idea, that wooden cars didn't last more than nine or ten years, but the idea I wished to convey was this, that you take a coal car for instance and build it today with the lumber you can purchase at the present time and let it run from eight to ten years, and it will cost you practically as much to put it in first-class shape as it did when you first started to build it. What I mean to say is that a large portion of the underframing will be so badly decayed you will have to remove it. Now I believe that lumber put into cars thirty years ago was air dried, your pine and oak was of better quality, had less sap, and would last much longer. You can spend quite easily more money in repairing a car than it costs to build it in the first place and then have a car in that way which will last thirty years. Probably that is economy, but it is a question in my mind; and I believe that from year to year our wooden cars are going to decay faster than they have in the past.

Mr. Chamberlain: When the last speaker came to me somewhere about 1882 or 1883, a good, husky boy from Nova

Scotia, he commenced his work on freight car repairs and also building new freight, and it was the same story as he reiterates now. We got our long timber from the south and we got our oak principally from New England, and much of it was put in repairs and new work inside of two or three months from the time it was in the tree, and that is the condition today, and it is the condition that is likely to continue for a considerable time, as long as wooden cars are manufactured. Railroad managers in a general way do not wish to go to the expense of procuring equipment that they do not want, and oftentimes matters come up making the necessity of new equipment a quick one. The time has gone by, and it even existed before I started railroading (and I am beginning to feel I am getting to be an old one) when dry timber is put into freight equipment as a general thing.

It sometimes occurs that in anticipation of new cars a considerable amount of timber is on hand when orders are given to discontinue the building, in which case the material is stacked up in the yard, but those cases are exceptions to the rule. The one in charge of equipment is not having a lot of lumber lying around in anticipation. The stock we are all trying to keep down as close as possible consistent with the service. When the time comes that the general manager wants some cars he wants them in fifteen minutes, and we get them out in twenty. (Laughter.) And these freight cars that Mr. Miller says are not lasting more than ten years, to my positive knowledge some two or three years ago I saw some of them running on the Albany road which he insisted in building in the 80's.

But it is a fact that the coal service is a hard one, not particularly to coal proper, but other classes of burning material, such as coke. We turn over coal cars to the New England Gas & Coke Company (now called the Massachusetts Gas Company I believe), they loading the same with coke. They pull it out of the ovens in a ventilated steel car or a special car built of bar iron or steel with spaces between the bars, and the very first thing they do in getting it into a steel car is to squirt salt water on it to cool it off, so that when dropping into the car underneath it will not burn the same, and why shouldn't the wooden timbers rot; and let me ask in this connection

under the same circumstances why wouldn't the steel car rust?

Now I rather think that the reader of the paper ought to have a chance to get back in rebuttal on some of the speakers that have spoken to a degree antagonistic to the steel car, but largely on account of local conditions. I think he ought to have the last say in the matter, and I presume that the President has that in mind and is going to ask Mr. McEnulty to give us a good rap if he can before the meeting finally closes.

I think I have expressed myself as clearly as I can on the subject, and I think I have said, so far as the truck was concerned, that I was a firm believer in it, at least in that style of steel truck known as the pedestal truck, and I further believe to a great degree in steel underframing too, but when it comes to the matter of tonnage and the cost of merchandise car in the neighborhood of some $700 with the steel car at a very much larger cost, I imagine about a thousand dollars, I cannot say with the local conditions that I believe existing in New England that there is economy in building steel cars at a capacity of 80,000 or 100,000 lbs.

THE PRESIDENT: Has any other gentleman remarks to make? I will say for Mr. Chamberlain's benefit that it is usually the privilege of the speaker to have the last word and presume Mr. McEnulty anticipates this, as he has a bunch of notes on a piece of paper; and if there is no other gentleman desirous of speaking, I will ask Mr. McEnulty to make his remarks in closing.

MR. MCENULTY: There seems to be a little misunderstanding in regard to just what is meant by a steel underframed box car. Mr. Chamberlain and Mr. Hunter have both condemned an all-steel box car for grain carrying purposes, and I heartily agree with them. A box car, to be referred to as having steel construction, does not necessarily have floor, sides, lining and roof of steel plates. That construction, as Mr. Chamberlain states, will not do for grain and is not even necessary for other classes of freight, either from the standpoint of first cost, or amount of repairs necessary. A good steel underframing and possibly steel upperframing with the remainder of the construction wood, is the type of car referred to in the paper.

I have no doubt that the statements made about the low average lading of cars is correct. This may be due to a large extent to the very small cubical capacity of a number of them, but it is not due to the load alone that a steel frame is advocated and heavier cars recommended. A car may meet the exigencies of the home road very nicely, but some day it will stray from the line and get mixed up in a train of heavy equipment on a coal road and its chances of coming back unscathed are very poor.

When making these notes I did not anticipate any one to see me.

The cars Mr. Chamberlain mentioned as having been built in the early sixties are the ones I referred to as now being used as ash cars.

I want to take occasion to deny the "soft impeachment" that I was running around in kilts in the sixties, as I was not thought of until ten or fifteen years later.

Mr. Doran spoke of wooden cars brought back in three months to be tightened up. He also spoke of the advantage of tightening up wooden cars every three months or thereabouts, and suggested that the same practice might do a steel car some good. A steel car once properly constructed needs no tightening and will not "loosen up" as Mr. Doran suggests. If one rivet gets loose there are others near the spot ready and able to perform its office.

There are many cars built where the railroad companies want to get them cheap, or are after first cost, and the design suffers—the cars are built entirely on designs of the railroad companies and are too light for the purpose needed; that is, they buy a car for 80,000 pounds distributed load and put a concentrated load into the car greater than that.

The cars referred to by Mr. Doran are of notably poor construction and a close study of them would convince anyone that they are not prototypes of our so-called modern designs.

Mr. Miller mentioned that you cannot get a wooden car built which in ten years from today will be good for anything, and Mr. Chamberlain's remarks about quick construction and green timber seemed to corroborate him, in a way.

I think all the points have been pretty well covered by the

speakers of the evening, and I have nothing further to say on the subject.

THE PRESIDENT: The discussion upon this subject is closed. The next order on the card is announcements, and I would ask the Secretary if he has anything in particular to announce.

THE SECRETARY: Nothing; only the subject for the November meeting. Mr. Purves says he expects to have Mr. Parkhurst, a member of the Association of Engineers, to present a paper on General Shop Practice, I think, but the exact title of his subject will be announced on the notice card.

(Meeting adjourned.)

TRIBUTE.

WHEREAS, We have learned, with deep regret, of the death of our venerated friend and co-laborer, MR. FITCH DAVENPORT ADAMS, therefore be it

RESOLVED, That in his death the New England Railroad Club has lost a long-tried and valuable member, one whose devotion to the interests of this Club were not exceeded by any one. The success of the Club is largely due to the energy, ardent and active interest taken by Mr. Adams as its first President, in the discharge of his duties in that office. In all the positions which he held his duties were discharged with untiring zeal and unswerving fidelity. His originality was marked, and his fund of information and pleasant humor were the delight of all his associates and friends.

RESOLVED, That we deplore the loss of a sterling friend, whose unwavering amiability made all our intercourse with him pleasant and agreeable, leaving none but the most satisfactory recollections.

RESOLVED, That in all the relations and duties of life which it was Mr. Adams' fortune so long to discharge, society loses a useful citizen, and his family a kind and indulgent father.

RESOLVED, That the officers of this club be requested to forward the family of the deceased a copy of the resolutions, with the assurance of our sincere condolence in their bereavement.

J. W. MARDEN,
J. T. CHAMBERLAIN, *Committee.*
J. M. FORD,

Mr. Fitch Davenport Adams.

Born in Canterbury, Conn., August 30, 1822.
Died at his home in Buffalo, N. Y., September 16, 1904.

Mr. Adams commenced car work with the Norwich Car Company at Norwich, Conn., in 1847, and remained with that company until 1853, when he went to Buffalo as contractor in the Buffalo Car Works. He was with that company until 1859. In the latter year he was made Master Car Builder of the Buffalo & Erie R. R., now a part of the Lake Shore and Michigan Southern Railway. From 1868 to 1870 he was Superintendent of the Ohio Falls Car Company. From 1870 to 1878 he was Master Car Builder of the Boston & Albany Railroad, located at Springfield, Mass. From March, 1878, until March 1, 1896, he was General Master Car Builder of the Boston & Albany Railroad, with headquarters at Allston, Mass., serving with distinguished ability until the latter date, when he resigned. He was one of the pioneer Master Car Builders of the country, and one of the oldest in the ranks of retired officers. He was a charter member of the Master Car Builders' Association; also of the New England Railroad Club. In both associations he was always actively interested.

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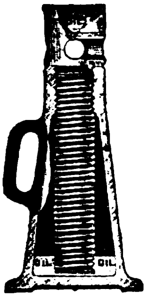

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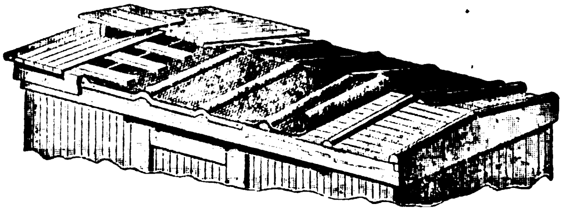

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New England Railroad Club,

November 15, 1904.

SUBJECT FOR DISCUSSION:

Modern Roundhouse Construction.

Paper by Mr. LESLIE E. MERRILL.

E. L. JANES, SECRETARY, 185 SUMMER STREET, BOSTON, MASS.

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The regular meetings of this Club are held at Pierce Hall, Copley Square, corner of Dartmouth Street and Huntington Avenue, Boston, on second Tuesday of each month, excepting June, July, August and September.

NEW ENGLAND RAILROAD CLUB

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$1.00 A YEAR. *Boston, November 15, 1904.* 15C. A COPY

A REGULAR MEETING of the New England Railroad Club was held at Pierce Hall, Copley Square, Boston, on Tuesday evening, November 15, 1904, at 8.00 P. M., President W. B. Leach in the chair.

The following members registered:

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Allen, C. Frank	Flannery, John J.	Murdoch, J. C.
Armstrong, C. R.	Gehman, G. W.	Millar, E. T.
Astley, H. E.	Genthner, G. A.	Moran, Andrew
Baker, C. F.	Goodwin, C. E.	Nesdell, F. F.
Barbey, F. A.	Graves, C. W.	Potter, E. E.
Bartlett, Henry	Graves, E. W.	Patten, J. W.
Bigelow, Chas. H.	Hayden, M. E.	Patterson, S. F.
Breed, C. B.	Hayward, Josiah P.	Pickford, Samuel
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Brush, G. M.	Hunter, D. W.	Rhine, A. K.
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Campbell, A. N.	Jewett, H. F.	Rich, Isaac
Chaffee, E. F.	Kanaly, M. E.	Richardson, A. H.
Chain, E. E.	Leach, W. B.	Sargent, F. W.
Desoe, C.	Lindley, R. M.	Sherburne, Chas. H.
Dietz, G. A.	Lord, G. W.	Slocum, Ernest F.
Duckering, C.	Marden, J. W.	Smith, Percy C.
Eddy, F. H.	Martin, G. W.	Smith, D. A.

Snow, J. P.	Towle, J. M.	Whitham, J. G.
Stevens, George F.	Webster, George S.	Whiteley, F. W.
Thayer, Albert	Wetherbee, F.	Wiggin, C. H.
Todd, L. C.	White, A. M.	Wood, Walter M.

THE PRESIDENT—The first business of the evening is the approval of the minutes of the last meeting, copies of which you all have and of which, doubtless, you have taken more or less notice. Those minutes will stand approved as printed unless some objection is offered. I might say, for the benefit of those who have not had an opportunity to read the Proceedings, that in accordance with the vote of the Standing Committee at their last meeting the notice concerning the death of our first President, Mr. F. D. Adams, is in those Proceedings, and there is also a picture of Mr. Adams on one of the last pages of the book. In connection with that I might add that the Secretary has on his desk forty or fifty copies of the photograph of Mr. Adams, and one may be had for the asking by any member who feels that he would like it.

This meeting, gentlemen, as you are aware, is being held one week late. That is entirely reasonable. It is particularly on account of the regular meeting night falling on the date of the national and state election. In our opinion the attention of the members would have been so occupied in their own places of residence as to warrant their remaining there on that occasion, and we were afraid that we would hardly get a sufficient attendance; therefore we postponed the meeting until tonight. While our attendance now is not quite what I would like it, still I think that on account of the postponement the meeting night may not have been thoroughly understood and remembered,—with the rather small attendance as a consequence.

The next item is the Reports of Committees. Are there any committees to report, Mr. Secretary?

THE SECRETARY — Ladies' Night Committee.

THE PRESIDENT — Well, as that is not a committee to report to this organization, that will more properly come under the head of new business. Are there any other committees to report?

THE SECRETARY — I know of none.

THE PRESIDENT — Is there any Unfinished Business, Mr. Secretary?

THE SECRETARY — Nothing in the way of unfinished business.

THE PRESIDENT — We will pass, then, to New Business. Under the head of new business the Secretary will read the names of four gentlemen who have been elected members of this Club by the Executive Committee this evening.

[The Secretary read the names of the following newly-elected members: George H. Burnett, salesman, representing Mix & Hartel, 102 Purchase Street; Winfield L. Larry, master mechanic, New York, New Haven & Hartford Railroad, Taunton; Charles A. Littlefield, connected with the Boston & Maine Railroad, Somerville; Thomas D. Simpson, general foreman, New York, New Haven & Hartford Railroad, Readville.]

THE PRESIDENT — Have you any other new business on your desk, Mr. Secretary? In connection with new business I might say that this time would be very proper for the consideration of a Ladies' Night, so called, and add that the Executive Committee has very seriously considered this proposition. The subject was referred to a committee to report to the Executive Committee this evening as to the advisability of holding such an evening, and it was considered advisable that it be brought before this organization as a whole, that they may consider it from the floor, speak on the subject if any desire, and that we may get an expression of opinion of this body regarding the same. Formerly, for an outing, or Ladies' Day, or whatever it might be called, this Club, as many of you know, held excursions,— generally some time during September. While those were very enjoyable, still we were unfortunate on one or two occasions on account of the weather, and gradually the outings were dropped. For some two or three years we had nothing. Then the question came up again, was considered by the Executive Committee, and it thought advisable to hold a Ladies' Night. For the last two years we have held such a Ladies' Night in this hall, consisting, as you know, of an entertainment, a lunch and a dance. While this

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has been very enjoyable to all of us who have attended, still there is a question now in the minds of the Executive Committee as to the advisability of holding another such Ladies' Night. Therefore, as I said, we would like an expression from the floor regarding this, in order that we may obtain the opinion of some of the members as to what they deem would be the most desirable form of such an entertainment. I would now be very glad to hear from any of our members. In the first place, do we want to hold a Ladies' Night or a Ladies' Day, or a social time? — anything you have a mind to call it. If we do, what form of an entertainment is desirable and how are we to know that it will receive the support — both moral and financial — of all or many of the members?

MR. C. H. BIGELOW — Mr. President and gentlemen, I should be very sorry, for my part, to see this Ladies' Night given up. I was sorry when the excursions were given up, for I had had the pleasure of attending only one, but enjoyed that one very much. I can state, for my part and my wife's also, that we have enjoyed the social evenings we have already had, and we trust that we will have another one this year.

THE PRESIDENT — Mr. Barbey, I have brought up the question of a Ladies' Night, or entertainment,— or anything we may be disposed to call it,— and I thought perhaps you might have some remarks to make on the subject. If you have, we shall be very glad to hear from you,— you being the chairman of the committee appointed by the chair from the Executive Committee.

MR. BARBEY — I had two doses of this Ladies' Night, and they came together. This year I really thought that the Club would drop the idea of having a Ladies' Night, but our President and a few of the other members thought we might as well try it again. Both years we have had pretty nearly the same thing. It is a pretty hard thing to get up a Ladies' Night at the time of year that we do that will meet the ideas of all our members. We have five hundred and some odd members of this Club, if I remember right,— 540 or 550. The last Ladies' Night we had we heard from about 85 or 90 people of the Club. It was not very encouraging.

THE PRESIDENT —That is, 85 or 90 members.

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Mr. Barbey — Members that came up to time. We sold about 300 tickets to about 85 or 90 members, averaging a little better than three tickets to a member that came up. On the floor we had that night about 150 people. It came to my mind that if we were going to have another Ladies' Night I wanted something a little better than 80 or 90 out of 550 members coming up to rush this thing along. Every meeting we have in our hall generally an average of about 150.

The President — Something like that.

Mr. Barbey — I thought it would be about as well to come up before the Club at large and ask them to express their opinion, or view, or advise as to some other form of entertainment whereby we could get all the members out. I have asked quite a number of members, and none of them seem to come right out and say just what they want. Some of them want a vaudeville show; some of them say the theatre; some of them say, "Let us have something to eat," and so forth and so on. This thing is going to take money. If you are going to have anything larger than we have had, you have got to have all the members of the Club put their shoulders to the wheel or tell us what they want, and we will give it to them. Now I would like to hear, Mr. President, what the members have to say in regard to having a Ladies' Night.

The President — Isn't any member interested enough in this undertaking to express his opinion?

Mr. Charles Duckering — Mr. President, I think that when these ladies' parties are given they are not very well patronized by railroad men because a good many of them live a long way from here and the parties generally finish late, and then a good many belong to various orders, such as the Brotherhood of Locomotive Engineers, Order of Conductors, and the like. They have their annual dance and other social functions connected with their several orders, and in that way generally get enough social intercourse with their families. I think that a vaudeville entertainment for men would be pretty well patronized. A local association to which I belong has once a year what they call a vaudeville smoker. It is kind of free and easy, and I notice that it is always well patronized,— the men seem to enjoy it. Then, too, we had

a dinner last year in town at one of the prominent hotels. It cost $2.00 a plate. I guess the dinner was worth about $1.25 or a little more, and the balance went toward the expense for invited guests and music. We had good speakers and an interesting time generally. Personally, I don't care for dancing, and I know there are a great many others like myself. I would enjoy a vaudeville show or a dinner, and would patronize either whether there was a cost to it or not, and I think there should be. Those who enjoy those things, I think, should pay for them.

MR. A. J. DESOE — My friend Duckering here speaks for the single man. The married men don't attend vaudeville shows. Organizations of which I am a member have not only had in connection with their entertainments a dance, but they have had an hour or an hour and a half of whist, as well, beginning at something like 7.45 and ending at 9.30 o'clock, and then an hour's entertainment, followed by the dance. We have had good success at it. While I have always purchased a ticket I have never had the pleasure of attending one of the Club's socials, and it seems to me each one of us ought to be democratic enough to support something of that sort, give the ladies a chance to get out and get acquainted with our fellow workers. I should be in favor of a Ladies' Night.

THE PRESIDENT —The gentleman who spoke a moment ago mentioned having a gentlemen's vaudeville, but it is not a stag party that we are talking about at the present time. It was with the idea of having us all meet here in a social way with our ladies, and letting the ladies "get busy," one with the other, also. We have not much time to spend on this subject, and we will pass along and let it take its natural course if we don't hear from some other member in a very short time.

MR. MARDEN — Mr. President, I move that we take the sense of the meeting by a rising vote as to the number in favor of a Ladies' Night.

[The motion was seconded.]

THE PRESIDENT — It is moved and seconded that we get the expression of opinion of the members present by a rising vote as to whether it is advisable to have a Ladies' Night or not.

[The motion was adopted.]

THE PRESIDENT — Now I will ask all those who are in favor of holding a Ladies' Night this coming winter to rise.

MR. HUNTER — Before that motion is put I would like to see the sense of the meeting as to whether they want a particular Ladies' Night, that is, a Ladies' Night with dancing or without.

THE PRESIDENT — It is simply the expression of opinion whether we should have a Ladies' Night, and the arrangement of the details would then be considered. Was that what you meant, Mr. Marden?

MR. MARDEN — That is right.

THE PRESIDENT — And I would ask all those who are in favor of this Club holding some sort of a Ladies' Night —

MR. BARBEY — I was going to say, in regard to dancing or other entertainment; that if the Club wanted a Ladies' Night a committee could very easily draw up a program for a Ladies' Night and submit it to the Club in two or three forms, say a concert in this room, a dance and a lunch, or a show right straight through that the ladies could attend, in the form of a vaudeville show, or a theatre party, or something of that sort. It is only a question of whether you want a Ladies' Night. Another idea I had in my mind was that perhaps we might as well clean out and run till next summer, and start in as we did years ago, have a trip down the bay, and a few of us get sick, and one thing and another. That might be a change, you know.

MR. HENRY BARTLETT — Mr. President, it seems to me surely we ought not to have another trip down the bay. I remember the last trip down there. Mr. Barbey nearly lost his life, and the band was carried ashore insensible. Personally, while I used to dance a good deal, I don't care particularly about it now, and it seems to me that it is desirable not to make dancing the chief card of the evening. It would seem to be all right to fill in a little bit after the other part of the entertainment with a little dance, but I believe that a vaudeville show, or something of that sort, would be more attractive to most of the members. Also, it is important that the affair be made free if possible. I don't mean exactly free, that it is not going to cost anything, but the idea of asking members to contribute 25 or 50 cents apiece, and with what the club can give

would make it as nearly as possible a free thing, so that everybody can attend if he wants to. The way it has been, as Mr. Barbey says, only eighty or ninety go.

THE PRESIDENT — No, you are wrong. Eighty or ninety buy tickets.

MR. BARTLETT — Eighty or ninety members buy tickets. They don't all go. It ought to be, it seems to me, a thing that the club in general can enjoy, and if any way can be devised to make it so, it would undoubtedly be a popular occasion.

THE PRESIDENT —Those who are in favor of holding some kind of a Ladies' Night this coming winter will rise.

[A rising vote resulted in favor of holding a Ladies' Night —64 Yes, 2 No.]

THE PRESIDENT (addressing the two members who had voted "No.") — That is right, gentlemen. I am glad you have the courage of your convictions and rise if you don't believe in it.

MR. MARDEN — We have taken an expression of opinion of our members. I don't think we can do any better now than to leave the details of it to a committee.

THE PRESIDENT — I beg pardon, we did not vote that we wanted one.

MR. MARDEN — No, we voted that it was desirable to have one, which means practically the same thing. If we do have a Ladies' Night we have got to put our hands in our pockets and pay the expenses.

THE PRESIDENT — For the benefit of the Chair I would be very glad if any man who would be willing to spend $1 for two tickets, if he were called upon to do so, towards the support of this Ladies' Night, will rise.

[Nearly every one present rose.]

Now, Mr. Barbey, you can see how many gentlemen are on their feet tonight. Thank you, gentlemen. Then, as we have an expression of your opinion, the Executive Committee will further consider the subject. This is closed.

Is there any other business to come before the meeting? If not, if no member has other new business we will pass to the subject of the evening, which is to be a paper on the subject of *Modern Roundhouse Construction*. The paper will be

read by Mr. Leslie E. Merrill, of the Boston & Albany Railroad. I want to say, on behalf of Mr. Merrill, and also in a spirit of compliment to him, that he has had only a few days in which to prepare this paper. Another paper was expected to be read here this evening, or, rather, last Tuesday, and at the eleventh hour the gentleman failed us for that meeting. We immediately attempted to communicate with Mr. Merrill, who was then away, with a view of having him prepare a paper for tonight, the postponed meeting, and it was some days before we were able to locate him. He has had, as I said, only a few days, and therefore he is entitled to our thanks and also to excuse if everything is not just as he feels that he would like to have it. I now take pleasure in introducing Mr. Merrill, one of our members, who will favor us.

MODERN ROUNDHOUSE CONSTRUCTION.

Mr. President and Gentlemen of the New England Railroad Club: —

The task I have undertaken this evening seems almost useless. This ground has been covered so often by men who have had many more years of experience than I, that it seems almost hopeless to try to advance anything new. Indeed, many of these men have met and solved some of the problems of the modern engine house. And yet, gentlemen, I hope in the succeeding discussion some of you, at least, may find something new and of benefit.

The subject of "Modern Engine Houses" can be approached from various points, but I shall confine my attention to those points only that touch the motive power department.

To my mind the discussion of this subject falls under several distinct and separate heads.

The shape of the engine house naturally comes first; then the location,— that is, the location of the house relative to the yards, cinder pit, the coal pocket, the sand house and the water tanks; then follows the architectural design; then might come the internal arrangements for light, heat, ventilation, also the method of providing for water, steam and com-

pressed air; then the disbursement of supplies — oil, waste, engine supplies, etc. And we must not forget the comfort of the men.

You have no doubt noticed, gentlemen, that so far I have made no mention of providing for engine-house repairs. I have left this until the last, for, to my mind, this question is of the greatest importance.

Up to within the last year or two it would have been useless to discuss the shape of an engine house. It would be taken for granted that the house would be round,— in fact, round-houses and engine houses are synonymous; and yet lately there has crept into the minds of some a question as to whether or not the circular engine house is the most practical and economical form. I shall endeavor to show the points in favor of a rectangular house as brought forth by the advocates of the same.

Perhaps it would be well for me to outline what I mean by a rectangular engine house. [Sketch.] You see the idea is this: It is in form like a repair shop. Here are the two wings, and here is the transfer-table for handling the engines. Here is the entrance track. The advantage claimed for this form of house is the economy of space. You see, gentlemen, by this illustration that the engine house in form is nothing more or less than a repair shop with a transfer-table.

The advantage claimed for this house is, first and foremost, economy of space. You all realize that when it is necessary to build an engine house in a congested district this question of space is of the greatest importance. Let me give you some figures.

A 50-stall rectangular house, with 2 rows of 80-foot stalls and a 70-foot transfer-table pit, making in all a house 375 x 230 feet, will cover 86,250 square feet; while a 50-stall circular house, with 80-foot stalls and an 80-foot space between the house and the turn-table and a 70-foot turn-table, a circle with a total diameter of 309 feet, will cover 120,000 square feet. Again, the most approved design of rectangular engine house calls for a covering over the transfer-table pit. You gentlemen who have operated railroads in these latitudes will appreciate what this means.

It solves at once the question of snow and ice. This has always been a problem to the engine house management.

Another decided advantage of the rectangular over the circular form is its ease of enlargement. It has often happened that a road has built a circular engine house at a large expenditure of money only to find in a few years that the demands of the service had outgrown the size of the house. When the entire circle of the house is completed, then nothing can be done to satisfy these increased demands of the service except by building an entirely new house. And now we turn to the rectangular house and see how easily the problem is solved,— you have but to extend your buildings and transfer-table pit and the difficulty is met.

These are among the advantages of the rectangular over the circular house as put forth by the advocates of the former.

I have not touched on the matter of heating, lighting and ventilation. It seems to me that the solution of some of the questions as to the relative merits of the two forms of houses can only be found when some road erects a rectangular house of 50 or 60 stalls at some point where the service is exacting.

And now, gentlemen, as to the location of the house: there is no question but what an engine house should be located as close as possible to the point where the engine is required for service.

As to the relative location of the cinder pits, the coal pockets, the sand house and water tanks, I have made a rough sketch on the board of what seems to me to be a good arrangement.

On the back side of this board I have made a rough sketch of the engine terminal at Oelwin, Ia. I have made some slight alterations, but their scheme is about the same. The engines enter on the main track, coming to D, which is the cinder pit. On one side I have drawn a second line just to show the depressed track. They use this method of handling the cinders. The engine comes, takes coal on same side, in this coal pocket C,— by the way, the elevated track is used here,— and then goes along to B, and there the sand is handled. You notice that this track goes right through the sand house. That is, a hopper bottom car, loaded with wet sand, can be pushed

into this sand house, and the sand can be let down into the bins, and from there into the driers. Compressed air is used to elevate the sand when it is let into the bins and there stored. The engine, after taking sand and water here, passes over a common switch to enter the house. The engine going out of the house goes out by this switch on the other side. In the design I have had the water tank A serve both tracks. Thus water can be taken on either side, sand can be taken on either side, coal can be taken on either side, either on an incoming or outgoing engine. I have dotted here a cinder pit. I, myself, don't see the necessity of it, but their plans call for a cinder pit on the outgoing track. And this cone switch seemed to me the best because the switcher would come in here clean, take sand and coal, and then pass out without interfering with the turntable.

Of course we all realize a definite plan cannot be determined upon,— so many local conditions enter in.

And now we have located the engine house, it might be well to enter into the architectural design of the same. The motive power department requires the architect to fulfill certain conditions. He must provide ample space front and back of the engine to get around with trucks, wheelbarrows, etc. The house must provide enough space on both sides of the engine to easily perform the repairs. The tracks within the house must be long enough to enable an engine to be moved front or back part of a revolution without necessitating either the opening of doors or slipping of the wheels.

Then comes the question of light, heat and of ventilation, and we will take up these latter problems with the architect. We all realize that too much light cannot be provided in an engine house. Provide plenty of windows of large size in the outer wall, and then head the engine into the house where the front end — where a large part of the repair work is performed — can get the benefit of the light from these windows. The amount of light in the interior of the house can be increased greatly by generous and frequent applications of whitewash. I am sure, gentlemen, that you can all appreciate the necessity of providing an engine house with a thorough system of electric lights.

The question of heat is not so easily solved. You all remember the old coal stoves, many of which gave out more smoke than heat and were a continual source of trouble. Then some roads tried methods of putting coils of pipe along the side walls of the pit and forcing live steam through the same. This at best seemed unsatisfactory. The piping was apt to be wrecked during the summer months, requiring almost a new equipment in the autumn.

Since the advent of hot air, the trouble of heating an engine house has been greatly reduced. Some of the houses already built have been heated with hot air by suspending the air duct from the roof, making the same of galvanized iron. I don't know whether I have made that plain, but I have seen a house thus equipped. It was a house with a pitch roof, and the air duct was hung in the centre of the roof, following the curve, and wherever they wanted to cut the air out of the main duct to heat the house, small side ducts were arranged with ventilators. But it seemed to me that the great mistake of having a house heated in that way was that you heated the air in the top of the house instead of heating it down where the heat was required, a good deal of the heat passing out of the ventilators. A good many of these ducts were made of galvanized iron. This was unsatisfactory in that it exposed the air duct to the action of the smoke and gases of the house, in many cases ultimately requiring the renewal of the same.

The latest design calls for a concrete air duct completely encircling the house at either the inner or outer walls. Side passages of soil pipe may be used to carry the heat from this duct to the pits. By the way, the latest design that I have seen of a pit, the air was admitted at one end and also at the side of the pit; that is, they admit it at the end nearest the duct, and also carry the passage of air off by the side, and both of these side passages are controlled by dampers. Exhaust steam from the air compressor, stationary engines and pumps can be utilized to furnish heat.

The ventilation of an engine house is an important matter. Ventilators should be provided over the pits and placed in such a manner as to be over the steam dome when the engine is standing in the house. The monitor top seems to be an

easy solution of this question. Being rectangular in shape it can be so placed upon the roof as to accommodate the various positions of the steam domes of different classes of engines.

And now, gentlemen, we must provide the house with steam, water and air. These three elements are considered very necessary in houses of large size. Various methods have been used, but the following seems to be as good as any: Have the supply pipes come to the row of posts nearest to the centre of the house; then run three lines of pipe completely around the house, providing the necessary drops and traps. It has always been considered necessary to provide a steam pipe located in this manner, with some means to take up the expansion,—expansion joints, loops, etc. But I have just seen a pipe installed in a house of 42 stalls without any method provided to take up this expansion except the natural increase in length of the radius, and so far this line of pipe has given no trouble.

The method provided for washing out locomotive boilers is one that should be given serious attention, especially in those districts having bad water. Some way should be provided whereby boilers could be washed out with hot water,—the reasons being that it is less injurious to boiler and fire box than cold water and that the engine can be placed in service quicker. A good plan is to provide a hot well and connect it with the exhaust of the compressor, stationary engines and the pumps, and through a system of piping to connect it also directly to the blow-off cock of the locomotive. A good many object to using directly the water that is blown off of an engine, in that it is charged with whatever sediment the water carries, but if you place a reheating coil in the hot well of course you do away with the sediment, and yet you utilize the heat that is in the blow-off water. This water for washing out can also be used for boiler filling. In this manner, you see, it is possible to fill a boiler with hot water, thus reducing materially the time required to place a dead engine in service. This piping of hot water and steam from engines to a hot well will enable us to keep the house comparatively free from steam.

I will say but a word concerning the care of supplies, oil, waste, engine supplies, etc. We all must realize the necessity

of keeping oil and supply room as near as possible to the engine house,— how close depends entirely on the situation of the particular house requiring it.

One of the important adjuncts of the modern engine house is room provided for the comfort of the men,—toilets, tub and shower baths, reading and sleeping rooms, etc.

And now, gentlemen, we come to the last but most important question,— the equipment of a modern engine house. What arrangements should be made to take care of the repairs to the power? I think we all agree in this, that the quicker an engine can be made ready for service after arriving at a terminal, the more money that engine will earn for the company, and the less number of engines it will take to handle the traffic.

In an engine house handling from 100 to 150 engines per day it is very necessary to have a machine shop located near to where the heaviest work is done, and, to my mind, it seems poor policy to equip this shop with old and worn-out machinery.

There is no place where quick and accurate work is needed more than in an engine-house machine shop. A large and small lathe, a planer, a shaper, a drill press, a bolt cutter, an emery wheel, and, when the shops are at a long distance, a driving wheel lathe and a wheel press are among the necessary machines.

Near the machine shop of our modern engine house should be located the drop pits for removing driving wheels, engine truck wheels and engine trucks. Perhaps the necessity for the latter is not at first evident. This pit can be used when it is necessary to renew cylinder bolts, to work on the truck, to renew engine-truck springs, etc. A traveling crane should be provided over these pits and so arranged as to cover one or two adjoining ones. Its usefulness can be made to cover the changing of air pumps, steam dome work, steam chest and cylinder work, etc. Adjacent to this machine shop should be located the tool and storeroom.

There is frequently considerable loss of time and money by not having the necessary tools or material at hand. As much, if not more, care should be exercised in keeping up the stock

in an engine-house storeroom as in one attached to a shop. Often an engine-house foreman is criticised for having an engine out of service when the fault is really with the storeroom.

The custom of robbing engines is the direct outgrowth of a poorly supplied storeroom. It is needless for me to explain what a decidedly bad practice this is.

When possible a combined blacksmith and boiler shop ought to be also attached to the machine shop. Two or three portable cranes should be provided for use in the engine house. Benches, vices and wrench racks should be installed at convenient intervals around the house.

A place should be provided for everything, and the men should be told that everything *must* be kept in its place. Right here, gentlemen, I want to say that too much emphasis cannot be put on this word "must." Is it cheaper to pay a machinist 26 cents an hour to hunt for a wrench than to pay a helper 15 cents an hour to put it in its place? Whatever can be furnished in the way of mechanical contrivances that will reduce the time or the muscular energy required to perform a certain operation will re-act directly in reducing your engine-house expenses, also decreasing the time an engine is out of service for repairs.

A man can produce about so much muscular energy in a day. If you see fit to use all this energy in one operation, then this man will work at a greatly reduced efficiency for the remainder of the time.

Take, for instance, the renewal of a steam chest,—compare the time and men required to perform this operation with and without a portable crane. This is but one of the many operations in which labor-saving appliances can be used.

It has only been possible for me to touch upon these various points of importance in considering the modern engine house. I have not dwelt at any length upon the coal pocket, the cinder pit, nor the sand house. While these are not directly a part of the engine house, they are so intimately associated with it that it is hard to separate them. I have made no mention of the improvements that have been wrought at the turntable, of the question of smoke jacks, of drainage, of fire protection, nor of engine-room facilities.

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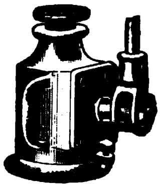

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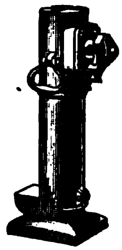

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I have not dwelt at all upon the problem of the organization of an engine house. While this does not come directly under the subject this evening, it seems to me one of the most important questions. The attitude of the men toward the management has as much to do with the efficiency of the house as the equipment.

I could give but scant notice to the very important subject of the engine house repair shop, of the store and toolroom and equipment of same.

We hear much these days of the shops, of shop management, of methods of improving the shop output. The problems faced by an engine-house foreman are not necessarily the ones faced by the shop superintendent.

I am afraid, gentlemen, that the engine house has too little of your attention. The efficiency of the motive power is connected directly and intimately with the efficiency of the engine house. Let the latter deteriorate and the effect is immediately felt in the former.

In closing, gentlemen, I will say give the engine house its share of attention. Improvements there will repay you fourfold.

The President — Gentlemen, you have listened to the paper as presented by Mr. Merrill. There are a number of motive power gentlemen here this evening, as heads of departments, engine house foremen, etc., and I certainly trust that we will have an immediate and energetic discussion. Before calling on any one I shall wait a minute and see if some gentleman will rise.

Mr. Bartlett — I will start off by asking a question. The plan of the rectangular house I have considered considerably. An important feature of the engine house is turning the engines around. I want to ask, Mr. Merrill, how you turn the engines round in the rectangular house.

Mr. Merrill — Mr. President, I would like to ask the man that designed the rectangular house the same question. The only solution seems to be to provide a circular turntable outside, or a Y. The gentleman that presented this subject said that he could devise a scheme whereby a turntable could be

provided on the transfer table. He said that he could design a turntable of that description. He has not done it yet. But if he could do that, why, it would be quite an easy solution of the turning problem.

THE PRESIDENT — Now, Mr. Bartlett, after asking that question, can't you make some remarks?

MR. BARTLETT — I have never believed, Mr. President, in the rectangular house, for the reason that it requires a turntable with the transfer table, which is quite an additional expense. You have to have a turntable anyway, and you have got to have a transfer table besides.

That arrangement of ash pits, engine house, coal shed, and sand and water plugs, is a very good one. I am a believer in a double ash pit, which we have in effect in one or two places on our line. The double ash pit gives you an opportunity, if you get blocked on your main pit, to push engines by in a hurry or, in other words, short-circuit them. There cannot be anything better in general plan than that arrangement of coal shed and sand and water plugs, and main ash-pit tracks next to them.

We all, in designing engine houses in the past, have never figured far enough in advance to cover growth. I mean by that that engine houses have been built just wide enough to accommodate engines of the present day, turntables have been just long enough to accommodate engines of the present type. In a very short time we find the engine house is too short and the table is also too small. In my experience I am satisfied now that an engine house in width ought to be at least 80 feet inside. Where we used to figure a 60-foot turntable, now we ought to make it not less than 75, and it goes without saying that no table should be put in today in a modern house without a motor—preferably an electric one, if you can obtain current 24 hours; if you cannot, a gasoline motor is the next best.

The lighting of an engine house is another important thing. All the windows possible ought to be gotten into the wall of the engine house. The engines ought to head in where the most of the light can be obtained around the front of the engine, where the work is to be done. As for the lighting at

night, I am convinced that it is not desirable to have arc lights, as they throw a large shadow, which is undesirable in engine house work. I believe in the incandescent light, with plugs for attaching portable lights, and, for the main light, two incandescent lights in a cage on the wall of the engine house, which radiate right between the engines. These throw a good light and avoid shadows. Furthermore, they enable you to keep the wiring outside the building, simply bringing it in through the wall where the lights are fastened and thus saving the corrosion on wires due to gas, which is a most serious problem.

The floor, which is an important thing, should be made of brick, and at the risk of criticism I think the brick should be laid on edge, crowned to give drainage to the pits. I find that brick laid flat-wise break out in a short time.

One thing more I would like to say, Mr. President, before I stop. At the risk of riding a hobby I want to emphasize what I have said before, although it is perhaps a little bit out of the subject. I wish it were possible for papers to be printed and sent out ahead. When I read the subject of this evening, "Modern Engine House Construction," I did not quite know whether it meant engineering features of the building or internal arrangement, or whether it included the ash pits and all that sort of thing. Anybody could talk almost the whole evening on any one of these features. It would be a mighty desirable thing if a person could know before he came here just what line of thought the paper was going to take, and prepare himself thoroughly before he came.

THE PRESIDENT — Is there anyone here who would be in a position to talk to us, or make some remarks regarding the engineering problem of the modern engine house and its location and connection? I think there is such a gentleman present. I don't want to call his name, but I will in a minute. Mr. Rich, would you be willing to make a few remarks? Mr. Rich, gentlemen, one of our members who does not get here regularly.

MR. ISAAC RICH — Three or four years ago I built a small section of a roundhouse, only an eight-stall house, at Hyannis, which to a certain extent had the same general features that Mr. Merrill has spoken of in connection with this roundhouse

here. There was a cinder pit and depressed track for that purpose and a runabout track. But, owing to the ground and the very limited number of engines there at that time, it was considered better to put the coal pocket elsewhere. That came off the main line. Finally, by means of a 5 per cent. grade and a 7 degree 30 minute curve, the top of the coal pocket was reached. The cars inside the coal pocket ran out on to standards outside to the depressed track, there dumping the coal. The engine, in fact, went to the coal pocket and took coal first, then backed up and went over the cinder pit and into the house. When it came back it went around the cinder pit, up into the yard, and got the train.

Speaking about the interior of the house and the light, that house faced to the south, and the back of the house being to the north, it was practically all windows. Then it had large skylights in the roof, and the doors being to the south, the upper halves of the doors were all glass. That house was particularly light.

Regarding the floor, it was made of concrete, and it broke up the first season. Right alongside the pits there was a heavy 12 x 12-inch timber, bedded on concrete, alongside the pits in the engine house, to jack on. We found that a great success. That gave a solid support for the jacks without breaking up the floor. I think that a brick floor, especially well laid, and laid on edge and grouted thoroughly with Portland cement, will stand better in the house than anything I know of.

The smoke-jacks and ventilators were made of wood, painted inside and out with some kind of fireproof paint, or smoke-jack paint, I think it was called, and it apparently answered the purpose. They never have caught fire that I know of. That was about four years ago and they are still good. The roof does not leak.

There is one thing I don't like about the house, and that is the tar and gravel roof. That weighed, if I recollect rightly, about two hundred odd pounds to the square. A paroid roof, five-ply, I think, weighs about 74 pounds to the square. That makes a tremendous difference in your roof. Nobody ever goes up there. There is no occasion to get on the roof to shovel snow or anything of that kind, because it either blows

off or melts off, the same as on a gravel roof. I think the roof can be made very much lighter, and just as well, without putting on that tremendous weight. As a matter of fact, on that little house of eight stalls they put 30 tons of sea gravel, by actual weight, according to the weights in the cars which brought it down there. It seems to me a large lot of that weight might be saved by putting some other kind of a roof on.

The turntable was made small; it is too small now, being only a 50-foot table. I believe the gentleman said he thought every turntable ought to be at least 75 feet. And there is no chance to enlarge it except by tearing it down and building it all new.

The house itself I think was 75 feet inside, and there was plenty of room to get around the engine, both front and back. The track did not go to the back of the house within about 10 feet; there were bunters put there, to see if we could keep the engines in the house, and I think that down there they have succeeded pretty well. The arrangement seems to work well.

The water was from four 2½-inch driven pipes, driven 24½ feet, and as fine spring water, apparently, as you ever saw anywhere, was used for the engines. It was pumped into a tank and carried round through the house in pipes, and also supplied the standpipe out near the cinder pit, and the station, about 1,500 feet from the tank.

The drains from the house pits are run into one pipe and carried some 30 feet from the house into a dry well. That is, a dry well in this way; it was simply rubble-stoned up, with nothing but sand in the bottom. After a while the grease and waste that came down through the drains blocked it up and it was simply scraped a little bit, and that let the water soak off. The oil, or whatever it was, stayed on top of the sand, and that once every six months had to be dug out, or cleaned out, to allow the water to settle off. The drainage from the turntable pit no attention is paid to whatever. It simply goes down and soaks off into the sand, and that is the last we hear of it. Unless there is trouble some time in the water supply, the country being all sand, there is no need of any attention to the drains or turntable pit at all.

Everything so far has worked down there very satisfactorily,

and the house is so located that at least two more sections of eight stalls each may be built as an extension to the present one, without interfering with any of the present arrangements.

THE PRESIDENT — Does that water leach through the sand in the winter? How does the water get out of the turntable pit in the winter when the ground is frozen?

MR. RICH — They have very little frost. They take a crowbar and break a few holes through the frost and it runs off. As this was the way they did with the cement lining of the old pit, it was concluded that the cost of the cement might be saved and let the men make the holes through the frost.

MR. J. P. SNOW — Mr. President, I will add a few words to what Mr. Rich has said in regard to the construction of the building, which was not touched on in the paper of the evening.

Mr. Bartlett spoke of the ill effect of the engine gases on electric wires. The same trouble occurs with any sort of metal in roofs. Hence, I think it is altogether better to make the roofs wholly of wood. This can be accomplished nicely if a sufficient number of posts are used between the pits. In an 80-foot house, to make an economical roof, there should be four posts. Several years ago, when I first had anything to do with making plans for roundhouses, there was a great objection on the part of the locomotive department to posts between the pits but nevertheless we put them in, and I don't think that the men ever knew that the posts were there, at least they found them very handy to set boxes side of and hang up clothes and things on. They are also convenient for carrying pipes. I don't think that four posts in an 80-foot house would be any trouble whatever. This allows of circumferential purlins, as you might call them, spanning over the pits, on which the regular rafters of the roof can be placed, and requires no trussing whatever.

I have to disagree with Mr. Rich in regard to the roof covering. The engine gases not only trouble electric wires and metal roof trusses, but they also eat out the nails used to fasten paroid or ruberoid, or any ready roofing that is put on which needs to be nailed often. The gases will pass up through the joints of the roof boards underneath the covering and get at the nails. A tar and gravel roof needs very few nails. I think

it would be preferable to use asphalt instead of tar, but with the construction that I have advocated there is no trouble whatever in getting ample strength very cheaply to carry any kind of a gravel roof.

Nothing has been said as to doors this evening. My experience has been that they should always swing inward. A good many old houses have the doors swinging out, and I find that in other parts of the country a good many new buildings are being built with the doors swinging outward. Where there is snow, as there is here, that is very objectionable. In the roundhouses built on the Boston & Maine Railroad for the last ten years we have used a post between the doors made of four Z bars. The doors are made on 3-inch frames covered with three-fourths inch sheathing. When these doors are open they, together with the post, take up a width of 10 inches. That is about as close as you can pack them and have a serviceable post and hinge. The post, to be sure, is metal, but being on the front of the house it does not get the effect from the engine gases that it would in the roof. Also, it is down where you can see it and they keep it painted a little better than iron in the roof.

The matter of smoke-jacks has been touched on a little by Mr. Rich, he saying that in the house which he described they were built of wood, which is true of the houses now being built on the Boston & Maine Railroad. There is considerable trouble, however, with wooden jacks. The engine gases seem to eat the wood as well as other things, especially where it is not very thick. I believe that the lower portion of a smoke jack should be made of wood, but the upper portion, I believe, should be made of cast iron. There have been a few cast-iron jacks lately put on some of our houses, and, so far as I know, they are doing good service, although they are more expensive than they need to be. The tops of smoke-jacks seem to suffer more than any other part. The union of the chemical agents in engine gases with the damp atmosphere produces acids that corrode even wood. If the lower portion was made of wood so there would be no condensation inside the house, and the flashing through the roof could be handily done, and the top made of heavy cast iron, I think the combination would be cheap and durable.

The President — Cannot some of our division master mechanics or enginehouse foremen who are here tonight tell us some of their troubles and experiences.

Prof. C. Frank Allen — Mr. President, while the present matter is up I wish to say that Mr. Breed, who is a member of our society, and who is associated with me in my work, happened to be in the West last summer in the employ of a Western railroad, and was sent to Cleveland to get some information, and part of the information that he brought back related to roundhouses. In some plans that he brought back of a roundhouse of the Lake Shore & Michigan Southern Railway, he found some rather peculiar features of roundhouse construction that I think might be interesting.

The President — We shall be very glad to hear from Mr. Breed.

Mr. Breed — The Lake Shore & Michigan Southern Railway has recently built two roundhouses, located adjacent to each other, at Elkhart, Ind., — a freight roundhouse of 34 stalls and a passenger roundhouse of 16 stalls. The general design of both houses is similar.

One of the features which is particularly interesting is the design of the ventilators on the outside of the smoke-jacks. In fact, the design of the wooden smoke-jack itself is novel. A few dimensions may be of interest. It is a rectangular box about 12 feet across the bottom lengthwise of the stall. The throat is about 3 feet by 5 feet, and at the top, which extends 14 feet above the roof of the house, is a large bonnet. This rectangular smoke-jack of course extends down through the roof of the house to a point just above the smoke-stack of a locomotive. Beginning at the roof is another rectangular box, built about 6 inches outside of the smoke-jack and running up to the same height as the top of the jack. This leaves a space of about 6 inches between the smoke-jack and this outer box, through which the hot air from the roundhouse can escape. The same arrangement for ventilation is carried out at all of the jacks. Beginning at the front or turn-table end of the house, the general shape of the roof is as follows: — it has a flat, upward slope for the first 45 feet, then it pitches up on a slope of about 35° for the next 22½ feet to the ridgepole, which is about 41 feet

above the track, and then downward at the same pitch to the back wall. The smoke-jacks are built through the ridge of the roof, thus bringing the ventilator at the highest part of the house.

Recalling Mr. Bartlett's remarks regarding ample provision for future growth in designing roundhouses, these houses appear to fulfil his ideas to some extent by their unusual dimensions and ample track approaches. For example, the freight roundhouse has four tracks approaching it, two inbound and two outbound. On both of the inbound tracks is a cinder pit about 200 feet long, with depressed ash track between them. Also both the outbound tracks have a small cinder pit, or ash-pan pit, as it is sometimes called, which is about 40 feet lon.g These pits are located about 210 feet from the turntable. Approaching the passenger turntable are three tracks; two of these are provided with cinder pits about 120 feet long, while the third is a runabout track to get around the cinder pits. The turntables for both houses are 85 feet in diameter, but there is a distance of only about 70 feet from the turntable to the house. The houses are 90 feet, inside dimensions.

There is one track connecting the two houses, and under this track are also built in both houses drop pits for both driving wheels and trucks. In the freight roundhouse both the driving and truck drop pits extend over four stalls, whereas in the passenger house the drop pits include only three stalls. Locomotives occupying these stalls where the drop pits are located, head out toward the turntable, whereas in all the other stalls the locomotives head into the house, according to the usual practice. Over each drop pit stall is built a smoke-jack, similar to the one already described, to accommodate locomotives which are headed out.

The boiler house is located between the two houses. A tunnel runs from the boiler house to both of the roundhouses and around the inside of the back walls just under the floor. In this tunnel run the steam-pipes which supply heat for the buildings and also the water and the compressed air pipes. Steam-pipes are provided along the inside of the engine pits and large radiators near the outside walls of the buildings.

Another interesting feature is the arrangement for drain

ing the engine pits. Each engine pit has at its lower end a sump hole, which is perhaps 3 feet by 2 feet, with a heavy cast-iron grating over it. This sump hole is drained through a 12-inch pipe which also has a screen. This pipe empties into another sump hole, which in turn is drained by another 12-inch pipe, and this also is provided with a screen. I have been told that they have had a great deal of trouble from the engine pit drains getting clogged, and to overcome that nuisance they propose to carry the drainage from the pits through these three screens before allowing it to pass into the sewerage system. This system, of course, takes all the drainage from the turntables, the drop pits and the cinder pits, as well as the water from the down spouts of the buildings.

MR. MERRILL — Mr. President, I am still thinking of that smoke-jack. I don't see the particular advantage of that double jack. It seems to me the same effect could be produced if a certain row of holes was introduced in the smoke-jack body proper, just under the edge of the roof. Then the current of hot air rushing up through the jack would tend to draw out whatever smoke or steam collected near the jack. I imagine that double jack is to take care of the collection of smoke and steam that has accumulated in the top of the house, but it seems to me the same effect could be produced by introducing those holes, and not going to all that extra expense.

MR. BREED — I believe they have had trouble from inadequate ventilation in other roundhouses, and to forestall any such possibilities in these houses have made ample provision.

MR. WIGGIN — I should like to ask the last speaker if there is any trouble in heating that house.

MR. BREED —These houses have just been completed this last summer.

THE PRESIDENT —This house, then, you did not see.

MR. BREED — I saw the plans for these houses while they were in the process of erection.

THE PRESIDENT — It occurs to me that Mr. Wiggin's point is worthy of consideration. Wouldn't you lose a lot of heat there?

MR. BREED — I should think there might very easily be a loss of too much hot air through these ventilators unless some damper arrangement is placed in them.

Mr. Wiggin — My experience with engine houses is that it would be practically impossible to heat that house.

Mr. Breed — I see no reason why some damper arrangement could not be installed to prevent an unnecessary escape of air from the house.

Mr. Potter — Mr. President, this subject is of much interest to a locomotive engineer, of course. Locomotive engineers could all tell you, from their point of view, how they would like to have a roundhouse built.

The subject of ventilation I am interested in, because in the winter time not only the smoke and gas chokes you up when working on your engine in the house, but the creosote that falls from the moisture on the inside of the roof will burn the skin wherever it strikes you. It eats your clothes up.

But as you have got the engine house pretty well built here tonight and the turntable all right, I would like to refer to washing out the boiler that Mr. Merrill spoke of a little while ago. He suggested attaching a pipe to the blow-off cock, using hot water. I think I know of a better way. I have been running an engine quite a good many years, and I have seen engines washed out a good many times and helped to do it; but I must say that I never saw an engine washed out but once in my life that was washed out properly and right, and if it won't tire you I would like to tell you the story.

The washing I speak of is done by a device that a man has at New Haven. The boiler is washed through boiler checks with hot water. He works for the New Haven Company, the same as I do. He works in the roundhouse at New Haven. I recommended that he send a model of the device to Mr. Bartlett, and I think he did a while ago. Perhaps he remembers it. This device he has patented both in this country and Europe. He got it up himself. He is a laborer there in the house. It is just about as large as the Hancock injector, perhaps a little larger. He lays it on the floor beside the engine. To wash an engine out it is necessary to have a live engine on the next pit to you. He attaches one pipe to the feed pipe of the live engine, another of this device to the city water. Then two pipes from a double Y are attached to both feed pipes of the engine that he is going to wash out.

He washes that engine out through the boiler check valves,— where an engine should be washed out, I believe,— going upstairs and washing the stuff down from the top of the flues and top of crown sheet. The way they wash engines out nowadays,— they take out the mud-plugs, put a wire in there and rattle it round a little and put on cold water, perhaps. It doesn't amount to very much. The first thing you know your engine is mud burned. I don't think it will get mud burned if you wash it out with Tom Rossle's boiler washer.

I put my engine in the house in New Haven one day. I run, every other day, from here down there and back the same day. I have about two hours in the house. He went to work on engine No. 902, and in fifty minutes from the time he took the mud-plugs out I was on the table again under my own steam, the engine washed out and hot water in that engine all the time. As I say, he connected one pipe with city water, the other with the injector of the live engine and forced the hot water through both those boiler checks all the while. He took all the mud-plugs out. On this device he has another pipe that he forces hot water through, where he takes the mud-plugs out the sides of firebox.

Well, that engine never had such a dose of physic in all her life before, and it made her heart glad and the engineer's heart glad, too. You ought to have seen the stuff that came out of her,— scales three sixteenths of an inch thick and more, semi-circular in shape, which unmistakably came from the flues; it came out there in handfulls. After he had washed her out thoroughly he filled one gauge with hot water from this same injector on the live engine, shut off his city water, blew the steam in from that live engine into No. 902 till I had seventy pounds. At the same time the fire was lighted in the engine, No. 902, and, as I told you, in fifty minutes by my watch from the time he started to take the mud-plugs off I was on the table under steam, and she never lost a pound. The fire that was in her after they took the pipe off kept the steam up.

Now a saving device like that is valuable property to any railroad company and will save an immense amount of expense repairing boilers and fire boxes, for it does a thorough job,— washes perfectly clean,— and a clean tube will make steam

faster than a corroded one. The boiler makers say "It would hurt their business," and they don't want it used, for there would be less repairs,—seems to me that is a good recommendation for it.

While the boiler washer is used there is nothing but hot water and steam that goes into the boiler and that under a pressure of a Hancock inspirator at a force 40% greater than the boiler steam is used from. The owner of this patent, Mr. T. Rossle, has not much *"push,"* or it would be on every railroad today. He now has it in his cupboard at New Haven.

THE PRESIDENT—We have a gentleman with us tonight whom I have no recollection of ever seeing here before and whom I am going to call upon to make a few remarks in regard to roundhouse construction and operation, etc. In the first place I think he can tell us something of interest; but his speaking will be mutually advantageous, because, I understand, he is going to locate in the East, and it will allow him to receive a little bit of an introduction to the members of the Railroad Club, while at the same time giving us the benefit of his remarks. If Mr. White, previously of the Lake Erie & Western, will step up here where I am, if he feels inclined, we will be very glad to hear from him. Mr. White, gentlemen.

MR. WHITE—I would much prefer to make my remarks from my present position. The paper has been thoroughly discussed, it seems to me, by practical men,—men that are competent to discuss it and to criticise it, and I think it is a very able paper indeed. About the only thing that I would care to say, by way of criticism, is that to handle the number of engines that the author has proposed to handle,—from 100 to 150 per day,—he should certainly have two cinder pits. And another thing would be absolutely necessary in the country that I came from, where the question of leaking flues was of daily and hourly occurrence,—it would be necessary to locate another standpipe farther back from the roundhouse to provide for engines that were in back of the engine that was on the cinder pit. I did not see any provision for this in his sketch on the blackboard. With these few criticisms, Mr. President, I thank you for your courtesy. [Applause.]

THE PRESIDENT—As a speaker a minute ago mentioned fifty minutes for washing out a boiler and getting an engine on the table, I would just like to ask Mr. White, as he has come from a little different section of the country, what the average time is from the time an engine would be left on the pit with fire dumped, how long it would take before she would be under steam, ready to back out again?

MR. WHITE—Listening to those remarks I did not care to criticise them, because that is a record that I know nothing of. Where I came from the water is exceedingly bad, and a set of flues only run from three to four months. With a large engine we take out from 35 to 40 plugs, and they can't be taken out in less than 40 or 50 minutes. If we got an engine washed and filled up with cold water, or our water was lukewarm, and in service in seven hours, we thought that we were doing pretty well with the large engines. Now, we may be behind the times on washing boilers, but I don't think we are. We don't wash from the bottom; we wash from the top, the crown sheets, and the flues, and all over. But we can't do it in 50 minutes.

THE PRESIDENT—Thank you.

MR. WHITE—I would like to say that those must be ideal conditions for a master mechanic, and I think that he is just about as near heaven with those conditions as he can hope to be in railroad work. If he wants to get to the other end of the line let him go west, to a territory in Ohio where they have lime and salt.

MR. ELDREDGE—I would like to ask if that system of washing boilers that the gentleman spoke of over there could be applied to stationary boilers as well as to locomotive boilers.

THE PRESIDENT—Perhaps Mr. Potter would answer.

MR. POTTER—Certainly. It certainly could.

THE PRESIDENT—Any other gentleman?

MR. POTTER—I think Mr. Bartlett knows something about that device. Do you not, Mr. Bartlett? Didn't he send a model or a cut of it to you?

MR. BARTLETT—I believe we tried it, but I don't remember that we got any such record as that. If we did not, perhaps we

ought to look into it again. Mr. Smith, our master mechanic at Somerville, had it directly under his charge; perhaps he can tell just what was accomplished with it.

THE PRESIDENT — Mr. Daniel Smith.

MR. SMITH — Mr. President, I would say in regard to this boiler washer which Mr. Bartlett and Mr. Potter speak of, that the gentleman did come to Somerville and tried it there one day. He said he would come back again soon and see us in regard to it. That was some year or more ago. The apparatus is still there, and he never has called for it. I didn't think it was any improvement on our method of washing out boilers, which is by a stationary boiler and a regular boiler washer manufactured by the Nathan people.

MR. POTTER — I understand he did not try it.

THE PRESIDENT — Yes, they did try it.

MR. ELDREDGE — I would like to say that this matter is of such great importance that if there is any promise of its being as successful as the gentleman says it will and can be made, we ought to go into it further. I have heard a great deal about the water in the East as compared with the water in the West; the conditions in the East and the conditions in the West; and I will say that from boilers here, under Eastern conditions, we took out 10,000 pounds of scale this summer. There is a battery down at Quincy Market where we took about two barrels of scale out of each boiler. Those are Eastern conditions. Now, it takes me to clean out one boiler about a week, the first time I go through that boiler and get out the scale. At Springfield last week we took three barrels of scale out of each of two boilers. If there is some new invention by which we can get that scale out easily and quickly, and keep it out, I want to know something about it. I would say that the old plant I referred to did not cost us any more for coal in July and August than it cost us in January and February, with an increase of 100 per cent. in the business, due to the fact that we took out 10,000 pounds of scale from the boilers. It seems to me hard work to get that scale out, and it would interest the Railroad Club, and interest us people who are in stationary work also, to hear more about the invention which has been spoken of.

The President — Perhaps Mr. Potter had better send his friend over to see you.

Mr. Eldredge — I should be very glad to see him.

The President — Would any other gentleman like to say anything on that subject?

Mr. Bartlett — Mr. President, this question of washing out boilers is a mighty important one. I don't think any of us here, perhaps, have done as much in it as we ought to have done. We blow off the steam to the atmosphere, waste it. One of the best schemes that I have seen lately is where they have a water tank, and the steam from the boiler to be washed is blown off into the water tank and heats the water. Of course this saves the waste steam. I have also come to the conclusion that, except this device that Mr. Potter speaks of, a pump is the best arrangement for washing a boiler. I think what is wanted is force to drive the scale out. The ordinary injector does not have the power. Take it with a water tub and a pump which will handle hot water, and you have got the ideal economical equipment. There is no question that a boiler should never be cooled down, if it can be avoided, in washing out. Cooling down, if done, has got to be very gradual, or stay bolts are broken, seams started, and all that sort of thing, also cooling it down takes time from the service of the engine. It should be kept hot, and washed with hot water, filled with hot water, but I don't know of any way it can be done in fifty minutes.

The President — If you will excuse just a remark from the Chair, I was in the office of a superintendent of motive power recently, and had to wait a minute. I picked up one of the recent mechanical papers (I think it was the *American Engineer and Railroad Journal*) and I saw therein a device illustrated whereby in a bad water district they were enabled to change the water in the boilers of their locomotives frequently, and in a very short space of time, without the engine being reduced in pressure at any time. It was not really a washing out, it was simply changing the water and washing out what sediment and deposit would come out. The device, as I remember it, was attached to the blow-off cock, and another connection made further up on the boiler, I don't just remember where, and the

water was allowed to pass out and through a settling apparatus where the heavier particles were deposited and the clean water then circulated right round through again. Perhaps some of you have already noticed it. Anyway, it would be a very good article to look up now that the question is before us.

If no other gentleman has anything to say I would ask Mr. Merrill if he has any remarks in closing.

MR. MERRILL — Mr. President, in closing this discussion for the evening I would like to call the attention of the Club to what I consider the keynote of the situation in engine-house work, and that is the engine-house management and equipment. As I said before, the quicker an engine can be put into service after she has been cut out for repairs, the more money that engine earns for the company and the less engines are required to take care of the traffic. We spend a good deal of time and of thought in equipping an engine house with the proper appliances for performing this work in the shortest time, but I would like to ask you, gentlemen, if you give the same amount of attention to that other important subject, the engine-house management. And I would suggest most humbly to the subject committee that, at some future time, when there seems to be a dearth of subjects for discussion, they discuss the question of engine-house management and equipment and its relation to engine-house repairs.

MR. POTTER — Just one word, Mr. President. I want the gentlemen to bear in mind that I said fifty minutes from the time they took the mud-plugs out. I did not say from the time they commenced to blow off the steam — it takes some time to do that. I know my story surprises the master mechanics here, but it isn't the first time an engineer's story has surprised a master mechanic.

THE PRESIDENT — As there undoubtedly remains a great deal to be said on this subject, and as the subject of the next meeting we hope will be a paper on *Shop Management*, would the members, or any member, consider it advisable to continue this discussion over to the next meeting, with a view of allowing some of us to look into it further and perhaps to consider Mr. Merrill's suggestion as to engine-house organization? If I don't hear such a request or suggestion I will declare the

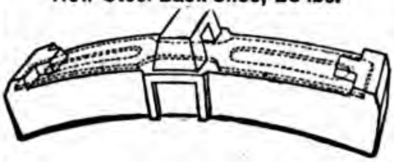
subject closed, but I will wait a minute to see if any one has anything to say. If we hear nothing further we will declare the subject closed.

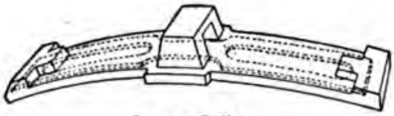
As I said a minute ago, the subject of the next meeting, as we anticipate now, will be a paper on *Shop Management*, by Mr. Parkhurst, of the Portland Company.

If any member would like one of these pictures of our late President, Mr. Adams, he is welcome to it for the asking.

If there is nothing more, I would say that as soon as we can walk in there quietly, after saying "How do you do" to one another, the lunch will be served. All those who are in favor of adjourning at this moment will please rise.

[Adjourned.]





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New England Railroad Club.

December 13, 1904.

SUBJECT FOR DISCUSSION

SHOP MANAGEMENT.

Paper by Mr. FREDERIC A. PARKHURST.

E. L. JANES, SECRETARY, 185 SUMMER STREET, BOSTON, MASS.

INDEX TO ADVERTISERS

NEW ENGLAND RAILROAD CLUB.

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The regular meetings of this Club are held at Pierce Hall, Copley Square, corner of Dartmouth Street and Huntington Avenue, Boston, on second Tuesday of each month, excepting June, July, August and September.

NEW ENGLAND RAILROAD CLUB

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$1.00 A YEAR. *Boston, December 13, 1905.* 15c. A COPY

A REGULAR MEETING of the New England Railroad Club was held at Pierce Hall, Copley Square, Boston, on Tuesday evening, December 13, 1904, at 8.00 P. M., President W. B. Leach in the chair.

The following members registered:

Adams, T. W.	Davis, D. E.	Handy, A. W.
Adams, W. H.	Dean, F. W.	Hartwell, H. B.
Allen, C. Frank	Dietz, G. A.	Higgins, J. G.
Armstrong, C. R.	Doran, S. P.	Hindle, W.
Ashton, Albert C.	Doten, C. W.	Holmes, S.
Averill, A. B.	Doty, Clark	Humphreys, James
Baker, C. F.	Duckering, C.	Janes, E. L.
Bailey, Chas. A.	Durkee, H. B.	Leach, W. B.
Banks, W. H.	Eddy, F. H.	Libby, H. L.
Barbey, F. A.	Ewart, John	Lindley, R. M.
Bates, Edw. C.	Fiske, Howard C.	Lindall, John
Bigelow, C. H.	Flannery, John J.	Littlefield, C. A.
Bodwell, G. Arthur	Gardner, Henry	Lord, G. W.
Cahan, F. D.	Gehman, G. W.	Lovett, Chas. C.
Carr, F. A.	Genthner, G. A.	Manning, J. P.
Chaffee, E. F.	Goodwin, C. E.	Marden, J. W.
Chain, E. E.	Gray, George	Martin, F. J.
Craig, Andrew	Graves, E. W.	Martin, H. F.
Craig, James	Greenwood, H. A.	Martin, G. W.
Curtis, F. M.	Hadley, F. C.	Mathews, H. B.

McCarthy, W. F.
McCombs, H. W.
McLaughlin, M. P.
Marsh, A. P.
Merrill, L. E.
Nesdell, F. F.
Patterson, S. F.
Potter, E. E.
Pickford, Samuel
Pirie, Robert
Probert, Joseph
Rhine, A. K.
Richardson, A. H.
Robinson, J. B.
Scott, Walter M.
Simmonds, S. W.
Simpson, T. D.
Smith, C. B.
Smith, D A.
Smith, Percy C.
Spencer, J. H. C.
Sprague, C. E.
Stock, Eustace
Sutton, G.
Swett, G. B.
Thayer, Albert
Todd, L. C.
Towle, J. M.
Vorck, F. W.
Webster, George S.
Wetherbee, F.
White, A. M.
Whitham, J. G.
Wood, Walter M.

THE PRESIDENT — The first order of business is the approval of the minutes of the last meeting. I might say that these minutes will stand approved as printed. They are all ready to be mailed, and will be mailed tomorrow, so that the members will receive a copy of them in a day or two.

Any committees to report, Mr. Secretary?

THE SECRETARY — No committees to report.

THE PRESIDENT — Any Unfinished Business?

THE SECRETARY — Nothing in the way of unfinished business.

THE PRESIDENT — Is there any New Business?

THE SECRETARY — New members. Your Executive Committee has accepted the following gentlemen as members of this Club: John McEwen Ames, mechanical engineer, American Car & Foundry Co.; Carroll Warren Doten, Instructor in Economics, Massachusetts Institute of Technology.

THE PRESIDENT — The gentlemen whose names you have heard the Secretary read have been elected members of the Club by the Executive Committee this evening.

Is there any new business that any member desires to bring before us at this time? Do you know of any other new business, Mr. Secretary?

THE SECRETARY — I do not, Mr. President.

THE PRESIDENT — For the information of those who might be glad to know, I would say that the Secretary has seen a letter which was written to one of our members by a member of the Executive Committee, Mr. Fred Smith, who was

general master mechanic on the New York, New Haven & Hartford Railroad, and who, as most of you are aware, is out in Colorado for his health. This letter stated that Mr. Smith was much improved, and that he felt that it would be but a reasonably short time now before he would be able to call himself well once more. Personally I was very pleased to hear of this, as undoubtedly are all who are acquainted with Mr. Smith.

If there is no other business to come before us at this time we will pass to the paper of the evening, which, as you are already aware by the announcement, is to be upon *Shop Management*, by Mr. Frederic A. Parkhurst. This notice seemed to me to cover in the words "Shop Management" a very large subject, without giving any definite idea as to what it would particularly treat of. I was fortunate enough a week ago to meet Mr. Parkhurst and have him show me a little of the working of the system which he is to tell us about tonight. Therefore I wrote to a number of our members, explaining what the paper was to be, that they might have a more definite knowledge of it. This paper, as Mr. Parkhurst is to present it tonight, necessarily, as I understand it, covers the subject in rather a broad way, and it is hard for him to put it in such a manner as to treat of the details without covering such a volume as to be perhaps tiresome. He presents the subject, as I said, in a broad sort of way, and he feels that questions which may be asked of him after he has read his paper will bring to a point any ideas that may not have been thoroughly treated. So that after Mr. Parkhurst has finished his paper, during the discussion, any questions may be asked of him, and I have no doubt that he would appreciate them, as they would bring out the details of particular branches of the system that would be hard for him to bring out in the paper itself. I take pleasure in introducing Mr. Frederic A. Parkhurst to the gentlemen this evening. Applause.]

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SHOP MANAGEMENT.

Mr. President and Gentlemen:

My subject this evening will be *Shop Management* and I shall endeavor to give you the outline of a system of shop management which I believe is slowly but surely becoming universal in this country. This system is more readily adapted to a plant manufacturing a standard product, but also gives excellent results when applied to a straight job or repair shop.

I wish to state at the outset that to my knowledge there is no book in existence today which deals with this subject in its entirety, though much has been written at various times on the matter. One of the most valuable as well as interesting meetings ever held by the American Society of Mechanical Engineers was that of June, 1903, in Saratoga, at which time Mr. Fred W. Taylor, who with Mr. H. L. Gantt developed this system, presented a paper of great value upon this subject.

The matter of shop management is every day becoming of greater importance to the manufacturer. He should have the most perfect control of his organization and that organization should be a machine of the most perfect parts available. This machine must be built for the special work which it is to do. Hence this system must be adapted to the needs of each organization to which it is applied. If the attempt is made to use each and every detail of it to cover widely varying conditions, failure may result.

The fundamental principle always remains the same, but the details of its operation must be enlarged or modified to meet the demands of the special machine to which it is applied. This fundamental principle is to reduce the cost of production to its lowest possible point and at the same time to increase the wages of the employees. It gives to the employer a daily balance in graphical form, so that at a glance he sees the work completed in his plant the previous day, what it cost, at what price it was billed, and the profit or loss on same.

Before outlining the methods of handling the orders and their work through the shops, it is necessary to have an idea of the organization required to do so. At the head of this organization stands the general manager, who has personal

charge of the business offices, and directly under him come the sales manager, purchasing agent, and book-keeping department.

The sales manager has immediate charge of sales and it is his business to get work for the shops. To do this he must see that the outside salesmen are attending to the proper canvassing assigned to them and that they are kept informed of all prospective buyers in their territory. He must see that the estimating department supplies each salesman with the necessary specifications and prices so that he may promptly and intelligently quote such prospective buyers. By his direction a proper solicitation of orders by mail is maintained and a "tickler" system employed to keep alive all correspondence regarding quotations, so that salesmen on the road may be furnished necessary copies of correspondence, quotations, etc., at proper time.

The purchasing agent is the one to whom the shops look for prompt delivery of material required either for stock or for orders in progress through the shop. Much depends upon him and he is too often blamed for the non-arrival of material which was never requisitioned from him until the shop was ready to use same. This common delay can be reduced to a minimum by a system of stores-ledger accounts and the proper handling of drawings and material lists by the planning department, as will be shown later. All quotations for materials and supplies should be kept by a purchasing agent in a card index, showing quotations received at different times from various vendors. The same card can bear on its reverse side purchases made.

The cashier stands at the head of the book-keeping department and it is he whom the general manager holds responsible for care of petty cash, bills receivable and bills payable, the pay roll, and the prompt billing of all orders. Billing is done by him in conjunction with a man who must be thoroughly familiar with all work done in the shops. This man must keep well informed as to prices received in other shops for similar work, must know the customers to whom he is billing work, and be able to so bill the work as to make a good profit.

We come now to the direct management of the shop. Here the general manager has control of the shops and employees

through the general superintendent. The superintendent through his heads of departments directs absolutely all that pertains to the maintenance and care of the plant and to the issuance and fulfillment of orders.

The duties of the superintendent are:

To see that all orders are properly transmitted to the planning department as soon as received and there entered upon the general graphical schedule.

To see that graphical schedule is made out for each order, showing time allowed for drafting, pattern making, purchasing, casting or forging, machining and assembling in erecting shop.

To see that graphical schedule is made out from the drawings to cover detailed parts needed to complete the order.

To see that schedule of shipment is made out four weeks ahead or as near that date as possible.

To see that all schedules are lived up to or to find obstacles and remove them.

To see that each foreman lives up to his instructions.

The organization under the general superintendent consists of assistant superintendent, chief engineer, shop engineer, chief draftsman.

The assistant superintendent, as the title implies, assists the superintendent in all ways, and when he is absent performs his duties.

The chief engineer is directly under the superintendent and directly over the engineering department, which stands at the head of the drafting room and includes the estimating department. The chief engineer oversees all estimates, designs and specifications and furnishes to the drafting room through the head draftsman all necessary information concerning orders. He must see that drawings for all work are gotten out in accordance with such orders and by latest approved designs. In this latter connection he should have established standards so as to make use of all detail parts which the shop is already equipped to manufacture. This point is very important in a plant manufacturing a nearly standard article. The design of a piece can oftentimes be slightly changed, thereby effecting a great saving in cost of machining, while at the same time its original efficiency and strength remain unaltered. Matters of

this nature should be taken up with the shop engineer. All drawings for the shops must pass through the engineer's hands for final approval before going to the planning department, from which they are sent to the shops.

The chief draftsman has charge of the draftsmen and drafting department. He is directly under the chief engineer. Modern practice today requires that all detail drawings for the shops be made to as large a scale as convenient and but one piece can be shown on a single sheet. This piece must be represented by as many views as may be necessary to make clear to the workman what is wanted. All dimensions must be clearly shown, finished marks to well define the surfaces, to be machined, and all allowances for press, drive, running or clearance fits must be given; also name of piece, its symbol, material to be used, number wanted, and if any special tools exist for its machining same must be shown on the drawings. This method applies to all work, be it casting, forging, wood, bolts, studs, etc., barring, of course, articles purchased outside, in which case the "bill of material" of the boiler, engine, machine or tool, shows what is required.

Drawings, after completion, are signed by the draftsman making same and then checked by the chief draftsman, or one called a checker, especially assigned to the work. Whoever checks the drawing must see that it is in accordance with instructions and specifications by the engineering department and that it contains all necessary information for the workman in the shops to finish the piece in question. No detail, however slight, must be left to the judgement or whim of the workman.

The duties of shop engineer, though entirely distinct from those of superintendent, are oftentimes of equal importance.

The great improvement in methods of doing work today and in machine and cutting tools make the position an exceedingly important one to any company wishing to keep up with the rapid advance being made in the prompt and economical production of work. There are few men equipped to do this work properly, for the requirements are extensive.

He must have a thorough knowledge of tool steel, especially the new high-speed, air-hardening steels, its forging, and the treatment of cutting tools, their shapes and cutting angles,

cutting speeds, the most economical combinations of cut, speed, and feeds, amount of power required to cut various metals and hence to drive different machine tools under different conditions; belting, the most efficient means of running belts, the best way of caring for them and the amount of power they will transmit.

A fair understanding of above heads will enable one to purchase and speed machine tools in an intelligent manner. The difference between doing this according to the best exact knowledge on the subject and by some one's judgment, no matter how good that judgment may be, is vastly more than most men realize.

It is also the shop engineer's duty to organize a tool-room system, to care for and maintain all tools, jigs and fixtures in the plant. All question of power plant and maintenance of same are in his hands.

The planning department is the fountain head from which emanates all instructions, drawings, and orders for the shops. An order, as soon as accepted by the company, is passed at once to the planning department, where it is given a number and entered upon the order schedule. It is then typewritten on the general order form and at the same time a card is made in duplicate, bearing the customer's name, address, shipping directions, date wanted, date of order, its number, and a short description of order. One of these cards is filed alphabetically and one numerically. One of the general orders is passed to the engineering department and another to the drafting room, and a third copy to cost clerk, to be attached to the cost sheet.

The members of this planning department consist of order-of-work clerk, instruction-card man, time-and-cost clerk, shop disciplinarian, and the gang bosses, speed bosses, inspector, and repair bosses, who represent the department in the shops.

The order-of-work clerk keeps a schedule showing the exact progress of work through the shops as it goes to different classes of men or machines. This is accomplished by the use of various order forms. These forms are exactly alike as far as ruling and printing goes, but differ in the color of both card and printing. For instance one may use a yellow order blank

printed in black for work which is to pursue an ordinary course through the shops. If he wishes to give an order precedence over one referred to, he uses a yellow order blank printed in red. If an order is to be rushed through the shops, having right of way over both of above orders, a red order blank printed in black may be used. If one wishes to have a piece of work rushed through the shops night and day, and to have precedence over *all* other work ahead of it, a red order blank printed in red is used. Rush orders of this nature should have the attention of one man, especially responsible, in their progress through the shops.

MACH. NO.	SUB DEPT.	STANDING ORDER.	ORDER NUMBER.

NUMBER OF PIECES.	DESCRIPTION.	NAME OF THE OPERATION.	NUMBER OF THE OPERATION.

MANUFACTURING NO.			DATE WANTED.			
P. CO. DRAWING NO.	DESCRIP. CARD NO.	SHEET DRAW'G NO.	MONTH.	DAY.	YEAR.	SIGNED.

To have these schedules work most efficiently a messenger system must be installed, with "in" and "out" mail boxes. The mail boys should make an hourly or half-hourly trip to convey orders, instructions, drawings, etc., from department to department.

The instruction-card man fills out in detail the instructions for doing each piece of work, giving in detail the order of each operation, what tools, jigs or fixtures to use, what speeds, feeds and cuts to use, and the time each operation should take. In case any difficulties are met with in carrying out these directions, the instruction-card man sees that one of the functional foremen removes the difficulty, or if this is not possible the order is corrected.

The time-and-cost clerk sees that all time cards are distributed to the men and that returns made on them are properly charged up to their particular cost sheets. A good series of time cards consists of three cards, used as follows: A white card suitably inscribed is put into a rack at each man's number. This rack is opened in the morning by the night watchman about a half hour before work begins and is locked by him when the whistle blows. Each man takes his own card as he enters the shop and it is retained by him through the day. He enters the time for each respective job on this card as it is completed. At night the card is signed by his foreman and is left in an opposite rack as he goes out. Said rack is unlocked by day watchman or time clerk, as case may be, when the whistle blows for closing time.

If a man gets to the plant late in the morning he finds the rack locked and applies to the time-keeper for a card, which in this instance is red but printed the same as the white card. No man can obtain credit for work if he leaves early unless he delivers his card, correctly signed by foreman, to the time-keeper. Overtime cards are blue in color but printed the same as the other two.

The shop disciplinarian settles all grievances and disputes of employees, also all cases of insubordination on their part. He may have charge of the hiring of help when there is no employment bureau. He must keep a record of the qualifications and characters of the men. All questions of help, whether of hiring or of settling disputes, is done in conjunction with the foremen.

The gang boss has charge of all material up to the time that it is settled in machines. It is his duty to see that all men under him have necessary tools and fixtures for machining any piece in question. He must know that each man and machine has at least one piece of work waiting, with the necessary tools, jigs, fixtures, etc., for use in machining. He must see that all work is settled in machines in quickest possible manner and, if needed, must assist workmen in so doing. He has absolutely nothing to do with work in question after it is set into machine and ready to be worked upon.

The speed boss sees that all machines are working at the

speed required by their instruction cards, and if a man is in need of help to get his machine to running on record time, he must pitch in himself and help.

The inspector is responsible for quality and accuracy of work turned out. Speed and gang bosses must see that work is done to his satisfaction.

The repair boss sees that the proper care is taken of machines, both as regards cleanliness and the use of same. It is his duty to maintain the belting and see that same has proper care. In this connection he must see that all belts are fastened correctly and running at proper tension. To do this he will have to use belt clamps fitted with spring balances so that all belts may be kept at required tension. In case of break-down, machine is placed in his hands and he takes measures to have same repaired immediately.

The leading functions of the planning department as a whole, as outlined by Mr. Taylor, are as follows:

The complete analysis of all orders for machines or work taken by the company.

A time study for all work done by hand throughout the shops, including that of settling work in machines, and all bench, vise work, transportation, etc.

Time study for all operations done by various machines.

The balance of all materials, raw materials, stores, and finished parts, and the balance of all the work ahead for each class of machine or workman.

The analysis of all inquiries for new work received in the sales department and promises for time of delivery.

The cost of all items manufactured, with complete expense and analysis, and complete monthly comparative cost and expense exhibits.

The pay department.

The mnemonic symbol system for identification of parts and for charges.

Information bureau.

Standards.

Maintenance of system and plant and use of the "tickler."

Messenger system and post-office delivery.

Employment bureau.

Shop disciplinarian.

Mutual accident insurance association.

Rush order department and the improvement of system or plant.

It is evident from the above outline of the planning department that each member of it should be carefully chosen, as this department is directly responsible for turning out the best work in the most economical way and, furthermore, must establish a discipline of the employees which will maintain proper order among them while at the same time it wins their confidence and good will. The success of any system of management must in a great measure depend upon the earnest and ready cooperation of all employees, and every endeavor should be made to convince them that the changes necessitated by the installation of this system of management all tend toward the betterment of each individual workman, as it gives him improved methods of doing work and at the same time gives him an opportunity of increasing his wages.

The planning department is virtually a bureau of information, for here is kept on file all orders, blue prints, schedules, stores, ledger accounts, pattern index, pay roll, cost sheets, correspondence file relating to orders, and in fact everything in relation to the shops and work in progress.

It is by means of the Gantt graphical schedule that the record is kept in the planning department showing in graphical form the status of each order in the shop. To carry this out several schedules are kept, namely:

The general order schedule.

The foundry schedule.

The requisition schedule.

The sub-order schedule.

In addition to these, on any large job a schedule is kept on that particular job, each item of which is carried out in detail.

I have with me this evening a copy of a sheet from each of the several schedules. These sheets are copies taken at random from the working schedules now in use at the Portland Company. with whom the writer is at present connected. These sheets, as will be seen by examination, are ruled into vertical columns, each devoted to a particular subject or operation.

SCHEDULE.

ORDER No																																																				
PART																																																				
SYMBOL																																																				
OPERATION																																																				
NUMBER WANTED																																																				
NUMBER FINISHED	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL	DAILY	TOTAL
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The cross-rulings from top to bottom represent days of the month and an entry of any operation or fact concerning work in question is noted on line representing the date of its occurrence. The top red line is the date at which work was to begin and the lower red line date at which it was to be finished. The black line represents date work was completed.

In this way we keep track at all times of everything which transpires in regard to an order. The value of these schedules depends upon an effective factory mail service, so that the operation orders after being completed can be returned to the planning department without delay. As soon as an order is returned, it is entered at once upon schedule and reference to schedule at any time shows what has been done and what has been ordered done.

The superintendent by running through these schedules daily can readily see what should have been completed each day, and if it was not completed, can promptly investigate and find out why it was not done.

We have now laid the foundation for the most important and radical change which this system contemplates. This is the study of unit times, the intelligent assignment to each man and machine a daily task, which will not be an easy one to accomplish and for the accomplishment of which he is paid a bonus of from twenty-five to one hundred per cent over his wages for the time taken to perform the task.

This bonus is rated differently on different classes of work. In a case where it is simply a matter of manual labor with cheap help percentage of bonus is low. A higher bonus is paid on work which entails manual labor and head work, but needing no particular skill. The highest bonus is paid where strength, skill, and brain work combine to the best results.

The study of unit times means a careful analysis of each and every operation into its various elements. With the aid of the stop watch all times are noted and tabulated for future reference. In a short time the planning department can have on file correct records as to time taken in handling and moving different kinds of work of various weights, and the time required to perform different operations on different classes of work.

Thus, by a scientific analysis of each of the various elements connected with any operation in the shops and with correct data regarding tools, machines, etc., it is possible for the planning department to issue instruction cards which give exactly the time each operation should take. The man must be considered when these times are set, as no two men work at just the same speed.

It is this study of unit times which makes this system stand out so differently from all forms of piece work. In this system the employer knows exactly how long it takes to do a piece of work and is thereby able through his functional foreman in conjunction with the planning department to show his employees how to do the work in the quickest possible time by the best methods. Thus the system accomplishes its purpose of increasing the output of a plant.

The employee is given an opportunity of increasing his wages by performing an assigned task daily and a bonus is added to his wages for obeying absolutely his working instructions and doing the work in the time set. The bonus is his reward for exerting himself to his utmost. Thus the wages of the employee are increased.

The limitations of one paper permit of but the merest outline of this system, but I hope that sufficient interest has been raised to warrant an investigation of its actual workings and advantages over the common organization.

The President — We have all heard the paper, and the subject is open for discussion. We have a very goodly number of members present, and we have some visitors here, and I trust that the visitors will feel just as much at home with us tonight as if they were members. If there is any information that they would like, or if they care to enter the discussion in any way, I trust that they will feel that I have extended to them as individuals a personal invitation.

Now, you know that I sometimes call the members by name. I hate to do it, and therefore to relieve me of this unpleasantness I trust that some one will arise and start the game going. There is no doubt in my mind, gentlemen, that after this thing starts and Mr. Parkhurst begins to answer questions, it will be

a little hard for me to decide to whom the privilege of the floor belongs.

MR. WEBSTER — Mr. President, it appeals to me that one of the very vital things that should be brought out in conjunction with this paper, and which appeals directly to the management of any establishment, is the probable cost of installing such a system, and how many additional employees would have to be had for a given number of men to carry it into effect. With that I will sit down and give Mr. Parkhurst a chance to tell us something about that.

MR. PARKHURST — In reply to Mr. Webster's question, I wish to say that the most successful plants in the country have been running with a ratio of non-productive labor to productive labor, as so called, of about six and seven to one. Now, it evidently makes no difference, in one sense of the word, whether the wages paid for getting out so much product is directed entirely to the workmen in the shops or directed to an apparently large office force, as long as the general payroll is kept down. If we can increase the production and reduce the cost, and hold the payroll down where it belongs, it makes practically no difference whether that, as I said before, is directed one way or the other. In point of fact, the idea of the system is to divide the duties that fall to the average foreman amongst a number of different men, called functional foremen, as Mr. Taylor outlines them, the object being to have one man attend strictly to one class of work and become proficient in that, another man take up another branch, and so on through the shops. As far as the clerical work is concerned in keeping these records, after the system is once installed it is comparatively light, because most of the work is simply routine work, copying the orders and making notations on the schedules, so that in point of fact the cost of it is no more than the maintenance of any other system.

MR. MANNING — I should like to ask how long this system has been in practical operation, and about how many orders at a time are in progress in the shops it covers.

MR. PARKHURST — Do I understand you to ask in what shops it is in operation?

MR. MANNING — No, how long this system has been in oper-

ation in detail, as you describe it, and also how many orders at a time are usually carried on in the shop in which this system is working.

Mr. Parkhurst — As far as the planning department goes, at the Portland Company in Portland we have had the planning department running, issuing orders for each and every operation in the shop, about four months, and that planning department is turning out anywhere from 150 to 250 operation orders a day. That will be increased, with a maximum amount of business, to probably 500 or 600 orders a day. Under a different system I have handled more than that with one clerk This Taylor system has been installed in the Bethlehem Steel Works for many years, and is working there today with practically no more clerical force than the ordinary system has in the average manufacturing concern. I might say here that at the Portland Company we have not yet come to the point of introducing the piece-work or bonus system, but that is now being gotten under way.

Mr. Manning — Mr. President, these extremely complicated systems of shop management and accounting appear very attractive and feasible as described by their inventors, and sometimes seem to work very well in practice for a few months, but I notice that in the strain and stress of actual operation for a considerable time, most of them are either very greatly modified or altogether abandoned. I have had occasion to try many promising schemes of shop accounting and I found that the simpler the plan, the fewer the operations, and the smaller the number of papers to be handled, the better were the chances of successfully enduring the test of actual service. The system reminds me in some features of one introduced into a locomotive works in this city a few years ago by a military gentleman, a colonel in the United States Army, I believe. Perhaps Mr. Parkhurst is familiar with it.

Mr. Parkhurst — Mr. Metcalf, was it?

Mr. Manning — It might be called a system of punching cards. It had been thought out very carefully, every contingency apparently provided for, and ample time had been expended in trying it at one of the government arsenals. A great variety of blanks were supplied, and to avoid writing, the

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workmen, timekeepers, and foremen were provided with punches, and the various records of time and quantities of material were made by punching spaces provided in the blanks. It was said to have been very successful at the arsenal, particularly in the matter of getting accurate costs of weapons and ammunition manufactured. The locomotive people adopted it with much enthusiasm and great expectations, but after some time abandoned it completely. In fact, when I made some inquiries of them, its very remembrance seemed exasperating. I think it failed because there were so many operations. The ordinary railroad shop of 300 or 400 men, making its own castings, tinware, duplicate parts, and manufactured articles for other departments, will have perhaps 2,000 orders running through the shop at the same time in addition to the straight repair work. It strikes me that this system that Mr. Parkhurst describes would in a short time accumulate such a multitude of papers and have so many people checking and rechecking, all of which takes time and much clerical labor, that it would be very weighty to handle. While it might be practical for new work in a manufacturing establishment, it would be a doubtful experiment to apply it to railroad service.

MR PARKHURST — In point of fact, the object of this system is to confine all the clerical work connected with the issuance of material and the issuance of orders to the clerks in the office, and to remove entirely from the foremen anything whatever to do with orders. The order is passed directly to the man at the machine, and a foreman does not have a file of orders and a pile of blue prints on his desk that he runs through, glancing over a general order, but having absolutely no idea of how the detail of that stands. He has nothing whatever to do with the requisitioning of material or the ordering of finished parts to be moved from one place to another; that is all taken care of by other help. It gives the foreman all his time to devote to the running of his shop. The amount of orders handled has been no material trouble to us for the simple reason that the work is done by clerks, who do nothing else. It is not as if the foreman had to do a lot of bookkeeping, and issuing material cards, and checking up orders and one thing and another like that. The material is brought to

the man and put down at his machine, where the order already is to do that piece of work, and all that the foreman has to do when that piece is machined is simply to see that the man puts on his time card what that order says, and he passes that order right into the mail box, which is hanging somewhere in the centre of the room.

MR. MANNING — In the ordinary locomotive works containing, say 400 or 500 men, how many clerks would you require, doing such work as that which the Portland Company does?

MR. PARKHURST — In the planning department? You mean clerks there to handle these orders?

MR. MANNING — The work in the entire shops using the system.

MR. PARKHURST — As far as the planning department goes there probably would be an order-of-work clerk, and two clerks to keep schedules, who could be boys or girls getting $5.00 or $6.00 a week. In addition to that you have the functional foremen, who are in the shops. All that the people I have named do is simply the clerical work in connection with making out these orders and the writing of schedules. Of course you have got to have the head of the planning department, the order clerk, in addition.

MR. ADAMS — I would like to ask Mr. Parkhurst if he thinks that this system could be sucessfully installed in a railroad car shop.

MR. PARKHURST — I think so, most assuredly, for the simple reason that in railroad shops — I am not a railroad man, but I speak from what I know of the business — you have a great deal of work to do which is duplicated. For instance, you have a lot of work to get out, and then in a month or two you have other work of a similar nature, so that you are doing the same thing over and over again, in one sense of the word. Is that so?

MR. Adams — Yes.

MR. PARKHURST — This system works to the best advantage in a shop of that nature, and in a straight manufacturing shop. Where I am now at Portland we do a big jobbing business, and we are putting the system in under the worst possible conditions for the reason that we have a job come in here today to

be routed and analyzed, and we may not have another job like it for six months or a year, if we do then, whereas in a straight manufacturing concern you go through that operation once and your records are kept. The next time that you have got a lot of driving boxes to get out you have got all your data handy that you had in the first instance, and the clerk simply writes out a new set of orders from the old, so that it is a matter of copying. That is about all that it amounts to in a manufacturing business. I might say that at Portland last year we had an order for fifty log bunks, and a great part of the work was carried out under this system. A bonus was paid on a considerable part of that work, all, in fact that was routed. When the two men assigned to the assembling started to assemble those log bunks, they took about six hours to assemble them. The time that I had figured out to do the assembling for two men was one hour and thirty minutes on each log bunk, and they thought that I was crazy. They worked on eight or ten of these log bunks, and the last thirty-eight were routed to the men at one hour and thirty minutes apiece, and they made a bonus of about $6.00 each on this lot. They assembled one complete every hour and thirty minutes. That shows that a careful analysis of the work and showing how to do it differently and better will improve the time that is ordinarily taken.

Mr. Manning — Mr. President, I should like to ask how many clerks the Portland Company actually employ in the entire works.

Mr. Parkhurst — What do you mean? How many clerks they employ in their works?

Mr. Manning — Yes.

Mr. Parkhurst — They have got there now, I think, somewhere in the neighborhood of 20 altogether, 20 to 22.

Mr. Manning — How many men have they?

Mr. Parkhurst — We have got on the payroll now 370 I think. On the last payroll we had 378 men.

Mr. Manning — That proportion of clerks would utterly kill the system for railroads, because you never could get a general manager or general superintendent to agree to have that number of clerks in proportion to the other force. The thing the

ordinary manager of a railroad dislikes to do is hire a clerk. It is easier at any time in a shop to get ten machinists than it is to get one clerk. As a rule it requires special exertions on the part of everybody concerned to get one. And as to getting twenty clerks, you would hardly find a railroad manager in the country who would agree to it. I think Mr. Parkhurst has the right idea; it matters not where the money is spent, as it is the output that counts. Whether you spend the money on a clerk or on a machinist it matters not, if you save in the long run. But you cannot make a railroad manager believe anything of the sort. You cannot make them believe that clerical work is anything but a necessary evil, to be limited to the smallest possible compass. As an illustration of the increased force required by this system, I recall that a locomotive company that I once worked for, and which was as large as the Portland Company, had just three clerks in its entire establishment.

MR. PARKHURST — If you should present to that general manager a chart showing the payroll of your shop for the last few months, and show him where, by the use of perhaps ten extra clerks, if you want to use an exorbitant number, you could cut off thirty or forty men, do you suppose that proposition would appeal to him then? I would like to say right here that in my experience I have never been up against that kind of a general manager, so that I cannot speak from experience on that. I would like to cite an instance, though it is not in the line of help. It was in the concern I was connected with before I went to Portland. I put an order system and a stores-ledger account in the factory, and I used to get up on the mat regularly before the president for the big expense I was putting the concern to. He told me one day that I had sunk $40,000 for him in the d———d old stock room, the way he put it. I did not say anything until we had everything running. That was some eight months after we started the stock room and the order system. It was not the Gantt system; it was a different system entirely. The result was that after we had that system running and were building machinery out of stock, instead of a monthly shipment of from 85 to 95 machines, we ran that shipment steadily from 125 to 145 with no more men;

in fact, we had less men on our payroll. We did have a little increased office force, but not much. The advantage of that was in keeping a proper stores-ledger account, maintaining our stock, and running the orders promptly. That is one of the points outlined in this system. But we did no routing. That had nothing whatever to do with the routing of work.

Mr. Merrill — Mr. President, I would like to inquire of Parkhurst about this stock account — keeping record of the material. That seems to me quite a serious thing in the railroad business, to keep a proper account of the material on hand. I would like to have him explain a little more thoroughly.

Mr. Parkhurst — I am sorry that I did not bring with me tonight a blank copy of one of my stores-ledger cards, showing how we keep our stock account. In the first place, we have no storehouse. We have two small storerooms. A great part of the stock is kept in the yard, and, in one instance, the boiler tubes in a lean-to, so that we have some trouble from men going to a pile and taking some material without turning in a material card for it, but we are overcoming that. For a stores-ledger card we have one which shows the date at which we requisition material, the date we receive it, and carry in addition to that a cash balance and a unit balance, so that by reference at any time to this stores-ledger card you can tell what you have in stock. For instance, let us suppose we are dealing with three inch by twelve foot boiler tubes. That card shows you the number of tubes you have got in stock, and the value of those tubes. Any material used is taken on a material card, which is signed by the man taking the material, which under this system calls for the storekeeper. The storekeeper sees that material is properly charged up, turns that card in himself to the stores clerk, who keeps the stores ledger. The deductions are made from that card, and the balance is carried out for entry. One clerk has no trouble in keeping a card ledger for stores of from 10,000 to 12,000 cards, and an ordinary manufacturing plant will probably have that number of cards in the stores ledger. In that way we keep a running balance, and we can run off the first of every month the amount of stock we have on hand,—

take an inventory of it, practically. The stock man, who comes in immediate touch with all this material, every time that stock gets low makes an adjustment, if necessary, and takes an inventory of what stock he has. He is going round among this stock continuously, and has one or two laborers to help him, as the case may be. If he has heavy work to handle he has to have more help, of course, than he does with light stock.

I don't know as that has answered your question just as you wanted it, but without a card I cannot explain very well how we keep them.

MR. MERRILL — Do I understand that the record of the material on hand is kept on a separate card?

MR. PARKHURST — Yes, sir. For instance, we have three inch by twelve foot boiler tubes. That card carries absolutely nothing but that size of tube. Now, if you have an order come in for a dozen boiler tubes three inches by six feet, and you have to cut them out of twelve-foot tubes, we deduct from the twelve-foot card the number of tubes you take. If you wanted six-foot tubes, you would take out six twelve-foot. That would leave the thing even. If, however, you cut them at nine feet, and left some short pieces three feet long, the twelve-foot card would have a credit for all the tubes taken out, but the card showing three inch by three foot tubes would be charged up with those pieces which were turned by the material man into that stock. That applies on structural iron work or anything of that nature, where the unit of it changes. Every bolt, every screw, every piece of machinery, every size of rope, every different weight of I-beam, and everything else is carried on a separate card by itself, so that if you consume some of this stock or some of the other the notation is made on that particular card.

MR. MERRILL — Suppose you had some rough material and it was turned into the machine shop and finished, and then returned to the storekeeping department again, is that material charged out on a separate slip or does it reappear again on the original slip.

MR. PARKHURST — No, sir, that material goes into what we call rough stock. All rough material is kept in a separate section called rough stock. It has there a separate value, does it

not? Now, when that material is drawn out, that stock is given credit for it, and the order to which it is drawn is charged up with that amount of material. Machine work is done on that, and when the piece is finished it has assumed a different value, and if it is put into stock, it goes into stock at its new value, which is taken from the cost sheet.

MR. HEINTZ — If a man goes into the stock room after a piece of steel a foot long, and you have to cut it off a bar, where do you cut it off? Do you send it to the shop and cut it off there, or do you cut it off in the stock room?

MR. PARKHURST — At present, in the Portland Company, we have to take that and cut it. To do this we have to carry it across the roadway to one of the shops, but when we get to the final arrangement there will be a cutting-off machine in the stock room. The idea is to keep all that stock together with the necessary cutting appliances, and the man in charge of that stock runs the machine.

MR. HEINTZ — How do you do with boiler plate, where a man wants to make a small patch and takes out a plate? Does the storekeeper follow the stock up and see that the balance is brought back into the stock room?

MR. PARKHURST — Exactly. It is in the storekeeper's record. The material foreman, as mentioned in my paper, is the man that really does that, for the simple reason that he is the man who moves this material to the job and away from it. He moves the plate to a shear; the stock is credited with that plate as it comes from the stock. When that plate goes back, instead of being a 48x96 plate it may be a 48x84. The 96 card never gets any credit, but the 48 x 84 card gets credit for it. In that way the stock is shifted.

MR. HEINTZ — Where you run your works at night do you adopt the same system as you do in the daytime?

MR. PARKHURST — Only in this way, that where we run a few men overtime we would hold the foreman responsible for the returns on the work. But ordinarily we arrange to overcome that trouble by having the work all laid out for the men before they go on the night shift.

MR. HEINTZ — Take a case where they are working outside, on some boats, and they are coming to the shop at all hours of

the night. Does the watchman or the foreman take charge of the material?

MR. PARKHURST—That depends. If the shop is shut down and nobody is there but the night watchman we hold the night watchman responsible. We have that case come up quite often.

MR. HEINTZ—That is where you have the trouble?

MR. PARKHURST—Well, we do to a certain extent, but not as much as you would suppose, because we have gotten the stock in such shape now that we can check it pretty easy if it is disturbed. It is very hard to do that, though, in a place where the stock is not properly housed.

MR. HEINTZ—I would like to ask, if you take a shop with 400 men, working on repair work, say 150 repair jobs, besides contract work, that is, machinery, how many clerks do you suppose it would take to adopt a system on that class of work?

MR. PARKHURST—For that class of work it will take twice as many clerks, easily, as it will in a straight manufacturing concern. That is evident on the face of it. It is the same way on lots of other clerical work in connection with the same kind of business.

MR. HEINTZ—It will take 40 clerks, according to that.

MR. PARKHURST—No, you don't want to misunderstand me on the number of clerks, because you must realize that when you go into a shop and install this system another is already running. You have got to get one system running completely before you wipe the other one out. That means that you have got to run two sets of clerks, practically. I can show you right in the Portland Company today where we have got two distinctly separate cost departments. During the period of transition it is necessary to do that, so that you won't wipe one out before you have the other running and wreck everything. That is why it takes extra men. But after the system is once installed the number can be reduced.

MR. HEINTZ—I would like to get your ideas on another point, but I don't want to do too much talking.

THE PRESIDENT—That is all right. We are all interested.

MR. HEINTZ—I would like to get your ideas about a cost clerk. Should he not be a man who would be thoroughly conversant with the machine that is built and its cost, that is, who

would know all parts of the machine and know whether it is right or wrong? He would have to be a good practical man, wouldn't he?

Mr. Parkhurst — Of course a practical man in that job would be very valuable. The point you have raised, though, brings to mind the condition of affairs in some cost departments which I have been familiar with. It was brought about by the fact that the cost department did not in the first place have proper data concerning the order. Now, under this system, if the cost department is handed a proper bill of material, the orders going out in connection with that and the schedule returns will show, when the cost man comes to check his cost sheet up, that he has not got returns from certain parts of that order. Of course a man who is thoroughly familiar with the job can understand those points better, but the question is whether he is an expert accountant, on the other hand. But that trouble is overcome by, as I say, giving the cost department, in the first place, all the data it requires.

Mr. Webster — Mr. Parkhurst—through you, Mr. President,—I would like to ask you one question. In conjunction with your designing department, and where the instructions are given as to fits of car wheels on axles, or driving wheels on axles, or a crank onto a crank shaft, you designate in thousandths of an inch what the fit shall be to the individuals who handle the two operations, one the turning of the shaft and the other the boring of the wheel or the boring of the crank. Isn't it possible that, taking that from a drafting room, and with the intelligence that a draftsman may have pertaining to actual, practical work, you would run into a great deal of difficulty, due to the different classes of material, for instance, like cast steel, some of which is very hard, other very coarse, or cast iron, some of which is very dense and hard, and other very soft and porous. How do you designate and take care of such conditions as those?

Mr. Parkhurst — I see the point that you are bringing up there. Allowances have got to be made, of course, for the material that you are handling, as you say, but how is a man going to tell any more when he bores a wheel out and makes his fit for his axle? He has got to make an allowance there

for his pressed or hydraulic fit, hasn't he? Now, if you are keeping an analysis of the material you are using you know pretty near what that iron or steel is, don't you? That being the case, you can have an established allowance for each inch of diameter, or any other way you are pleased to designate it. In addition to that, if you are running regularly against a different variety of material, of different elasticity, you will have to do that the same way as you would do some other things in the same line--you have got to make a table of allowances to govern those conditions. Take it on ordinary work, and under proper conditions, where you know the quality of the material you are machining, you can make your allowances absolutely right. I think you will agree with me on that, won't you? If you are going to run hard iron and soft iron, you have got to make an allowance on a table for them. The proper way, however, is to have all your material come to a prearranged analysis, so you are absolutely certain what allowances to make.

MR. WEBSTER — I think that you qualify that by stating rightly that it is the only way you can do it, providing it is left in that manner, but I anticipate that you would very likely have a great deal of trouble, if personal experience cuts any figure, in getting the fits correct. I know in crank-shaft work we have to have men who are very thoroughly experienced in that class of work, with the good judgment of our foremen, to get them and get them correct, because we find that steel castings vary like the sun, moon and stars, and so does cast iron. On that account we have great difficulty in determining just what is the right fit. It appeals to me that, having it come through the drafting room or designing room, you would get into difficulties, and the necessity of the case would be that you would in a very short time have to throw away an awful lot of work. It may be possible that I am mistaken, and if that difficulty has not occurred, why, I would like to know it.

MR. PARKHURST — I don't think so, for the reason that you can grade your work where it is being machined. As far as that goes you can grade it and tell about what you are going to have, can't you? You bore out a wheel, and you can tell pretty near what you have got for material in the wheel. Now, if your material is coming in such a way that you have got to

make allowances over the standard fit per inch of diameter, it will have to be done off a table, to govern the different kinds of material, just the same as you have one allowance for cast steel and one for cast iron, and perhaps for high tensile steel you might have another. But on the great majority of work that is done in the shops it can be done to internal and external cylindrical gages, and the exact allowances made for any desired pressure of fit. This is being done in all large shops in this country.

THE PRESIDENT — We have a lot of railroad men here tonight, and they wanted to hear this paper. I have not a doubt that many of them have some kind of a system that they are working or know something about. Then, there are the manufacturing establishments. We have a lot of the manufacturing managers here tonight, and they might tell us something that they have in their own little sphere.

MR. AVERILL — Mr. Chairman, as an office man I have been very much interested in the paper of the evening. There is, however, one item which is not quite clear to me, and which has not been touched upon,—regarding the disposition of certain labor. I mean shop watchmen, helpers, sweepers, and that class of labor. What disposition does Mr. Parkhurst make of that?

MR. PARKHURST — Do you mean in regard to what department we immediately connect those men with?

MR. AVERILL — Is it divided up on the cost of the work in process, or what department do you put it in?

MR. PARKHURST — That is put on to the maintenance expense. That comes into a fixed charge in the maintenance expense, because that is what it practically amounts to.

MR. AVERILL — As I understand it, then, you don't divide it up between the articles in process of manufacture?

MR. PARKHURST — No, that comes in on the general expense.

MR. MANNING — Mr. President, I should like to ask a little further on the cost of material matter. When an order is passing through the shop that requires material from different departments, say wood, steel, iron, etc., are sub-orders made upon the storekeeper to be filled by him, and are those orders

endorsed on the original order that comes back to the cost sheet, or what method is taken to assemble the various charges of materials from different sources on account of one order?

MR. PARKHURST — When the order is made out in the planning department to go to the shops the storekeeper has sent to him at the same time material cards, as we call them, requests to deliver to such and such a machine, machine No. 33 for instance, certain stock, it may be to deliver certain stock to the erecting shop, it may be to deliver certain stock to the boiler shop, and in each case it is specified, and to what machine it goes. That is made out and entered on one of these schedule sheets, and that schedule sheet is kept in the cost department and is checked over, so that when an order is closed the cost accountant sees clearly that every material requisition which was made out against that order has been returned to him, or if it has not been he can trace it.

MR. MANNING — Those orders come back from the storekeeper directly to the accountant, who has charge of the cost sheet; is that it?

MR. PARKHURST — No, sir, they first go to the man in the planning department who keeps the stores ledger. He checks them off. A note is made on the schedule that material for such and such an order has been delivered. The card then goes to the cost man, who enters it up against his respective cost sheet, and by reference to the schedule at the closing of an order he can find out whether any material cards have been issued for material of which he has not had the returns. This system makes an absolute check on that. It also prevents requisitioning material from the purchasing agent twice, as every requisition is numbered consecutively and put on a schedule, and the order number to which the material applies is entered on the schedule. No requisition is honored by the purchasing agent without the signature of the clerk who maintains this schedule, and the clerk by running over his schedule sees at once whether that requisition has been through once before or not. In that way we cut out this trouble of ordering material two or three times.

MR. HEINTZ — I should like to ask if you charge any item on your cost sheet that is general expense, — office hire and

watchman, etc. Do you make an entry on your cost, or do you allow anything on the cost for that expense?

MR. PARKHURST—That is run on a percentage, figured out every month and worked out on a percentage, depending on the amount of work done?

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his hands and to hunt for a lead pencil, and to begin to think what time he commenced and what time he finished, etc. On the whole, I think a clock is very much better.

MR. PARKHURST — In connection with the time cards I would like to say that I simply mentioned that way of keeping the time because that is the way we are doing it at Portland at present, although we contemplate using the clock as you say. I have used clocks before. That is the proper way to do it. It is one of those things which is perhaps a refinement of a detail, which can be taken care of later on ; but, as you say, that is the proper way to register the time. It removes then any question one way or the other, because the man stamps his own time and he sees on his card what time he is getting credit for.

MR. WHITE — Mr. President, some four years ago at Schenectady Mr. Gantt was engaged by our company, the American Locomotive Company. He came and was with us nearly two years. His method was adopted generally throughout the plant. In the foundry we are using it at the most of our plants at the present time. I am using it at Manchester. In the machine shop there was some little difficulty regarding it on account of piece work, as most of our work is piece and contract work. We have looked upon the matter of the premium plan as a stepping stone to getting correct piece-work prices for different work. We have used the premium plan as outlined by Mr. Parkhurst, keeping the accurate time of the man, giving him his time, and a percentage over that time if he made his time, or giving him the full time and adding to it besides. Accounts of each job were all kept, careful records being kept in the office. When we wanted to know what a job cost we referred to them, using them as a basis for establishing a piece-work price. Take the matter, for instance, of boring a cylinder. In the different plants there is a big variation in cost of cylinder boring. That is due very largely to the machines more than it is to the men. When we make comparisons between our eight or nine plants we can find what the trouble is. In the blacksmith's shop the stock is kept by the storekeeper. If the smith wants a piece of iron he goes to the clerk. That clerk gets the iron for him, or it is taken from the rack, a

piece is cut off, and returned. The amount that is used is charged to the job. That record is kept by the clerk and is turned into the time-keeping office, where the time on the job is kept. The system in the smith shop is piece work, the helpers getting a percentage of the output. For instance, in the case of a blacksmith with a single fire, the blacksmith has a certain percentage and the helper another. A fire with two helpers, three helpers, four helpers, or five helpers, is divided up in that way. I have found that this system works very advantageously. It is the best that I know of. It gives each one an interest in it, and each one works for it. It stops the lazy helper. When they find a helper in a gang that won't come up, the others will complain, will commence to make a fuss right away, and will get rid of him. In the boiler shop, driving rivets, we have the same plan. In fitting up, each man participates. The principal thing is to establish the first price, get that right, then the piece work can go along very easily and it requires less clerical help in a general way than the plan as outlined by Mr. Parkhurst.

THE PRESIDENT — We would like to hear from some other manufacturing establishment. Mr. White has told us what the American Locomotive Company is doing. I notice a number of men from the Hancock Inspirator Works here. Can't some of them tell us how clever they are up there?

MR. DURKEE — Of course, as the gentleman over here said, everybody will agree that there is no manufacturing concern that can be carried on today successfully without a system of some kind. I agree with him also when he says that whatever system may be invented must be adapted to suit the conditions of the particular business. Of course we have a system of our own, which we have evolved ourselves. We have gradually added features to it as we found it necessary to do so. It is not so elaborate a system as Mr. Parkhurst describes, but it seems to satisfy our needs, taking into account the volume of business that we do and the number of men that we employ. The Taylor-Gantt system, as Mr. Parkhurst has outlined it, seems to cover the ground admirably, and takes care of every detail, every contingency which might possibly arise; but there is one thing it seems to me it would do, and that is, if

it became universally adopted by all manufacturing concerns, it would create such a demand for clerical help that I doubt somewhat if he would be able to employ his clerks at the wage of $5 or $6 a week, the price which he named.

I would like to ask Mr. Parkhurst, before I sit down, how large, in his opinion, an establishment would need to be, or how many men it would necessarily need to employ, in order to warrant the adoption of this system in its entirety. It seems to me that it is possible to reach a point where it would be impracticable, and also too expensive to carry on.

MR. PARKHURST — You mean the plant too small, I understand.

MR. DURKEE — Too small, yes.

MR. PARKHURST — Well, if you have a small plant, the result is that one clerk can do more than his particular branch of the work. The man in the planning department, who plans all of this work out, could also, if he had a shop of fifty or sixty men, perhaps plan that work out and at the same time attend to some of the functions assigned to other men, so as to embody two or three jobs in the one, provided he had but a few men to look out for. That is a point which has never been brought to my attention very closely; in fact, I never have been in a shop employing that amount of help. I don't see why that should entail any more expense in proportion in a small shop than a large one; in fact, I think on the whole it would stay about the same. The object of it is, of course, to have the functional foreman attend to his particular duties, and another man to attend to each of the others.

THE PRESIDENT — Mr. Baker, don't you want to say something to us tonight?

MR. BAKER — No, I did not want to say anything, Mr. President. I would like to ask a question, though. What is the basis of the premium or bonus that you pay to men, Mr. Parkhurst?

MR. PARKHURST — The basis?

MR. BAKER — Yes, the basis; what you base your bonus on, or how do you get at the amount of bonus?

MR. PARKHURST — That is done by plotting off the cost under the day work system and the routing system, finding out in the

first place what the difference in cost to the manufacturer is, and that percentage runs on a curve which gives to the man the greatest bonus when the cost line, the cost to the manufacturer, is the lowest. It is plotted out on a curve, practically a parabola. That is what it amounts to. If a slight saving is made over the day work cost the amount that the workman gets is nothing. He has to come down to a certain point before he makes his bonus, and where he has reduced that cost materially, why, he gets a corresponding material increase in wages. I have paid a bonus on some jobs as high as 100 per cent., and in that case it has cost the employer about one third of what it did before, after paying 100 per cent. bonus. That, however, was an exceptional case. The bonus averages from 25 or 35 to 50 per cent., hardly ever over that, except under unusual conditions.

MR. DOTEN — I wish to inquire, along the line of the last speaker's remarks in regard to the time unit you speak of. How do you figure on time, to begin with? Then I would like to ask if you change the time unit with experience, and whether that would not be open to the same objection that the piece wage system is from the point of view of the laboring man, that you will decrease your time allowance for certain jobs as you find that men increase their speed?

MR. PARKHURST — It amounts to this: we establish the time, in the first place, by making a study of all the hand operations, and the operations such as transporting material and lifting it with a chain fall into the machine, and all of those elements which do not immediately concern the operation of the machine itself. After that we have to take into consideration the capacity of the machine. If the engineer of the planning department, if the order-of-work man, the construction man, I should say, routes that work to a machine and puts a time on there which is much too slow, why, it is time to get a new man to do the routing. That has got to be done intelligently, because you cannot route work to a machine and make the time so slow that the man can beat it three or four to one. It would be folly to do it that way. A man has got to understand his business thoroughly. But supposing that a piece has been routed, and the time set intelligently, and the man keeps inside of that time

on a long run, let us say, that time is not cut down unless the method of doing the work is different; a time once set, with certain tools to be done a certain way, is not changed. But if we do devise better means of doing it, or find that with a different tool or with a different machine we can better that time we feel we have got a right to change the instruction card, because the methods of doing it have been changed.

THE PRESIDENT—We have had only one gentleman tell us ——— Mr. Marden.

MR. MARDEN—Mr. President, personally I have been very much interested in the paper and the subject. First, because I believe in system. Second, because it has made our meeting tonight appear more like some of the old-time meetings we used to have, when the members got up and said something. I think the subject committee is to be commended for selecting the subject, and that Mr. Parkhurst is entitled to a vote of thanks for his paper, and for the interest he has gotten up in our meeting.

I believe we could have subjects in which most of us are interested that our members would be ready to talk about, and our meetings would be so interesting that our members would try and be present at every meeting.

We would then hear the experience of others expressed, which in my opinion is very much better than a paper read with no discussion on it.

I have no doubt but that Mr. Parkhurst will agree with me that while the system which he has explained is a good one, yet it would not be adapted to different shops and different methods of doing work unless it were modified to meet contingencies that arise in different shops.

I am not going to express further opinion of it tonight, although I have in the past had very decided opinions as to a system of book-keeping and methods of charging material and time in shops with which I have been connected. I know that there are those here tonight who are ready and would be glad to express their opinion on this subject, and I will sit down and give them a chance.

THE PRESIDENT—As Mr. Marden says, this has brought out quite a discussion, but as I was about to remark when Mr.

Marden took the floor, there is only one gentleman, if I remember correctly, who has told us — well, perhaps two, I will modify that — what they are doing in their shops. This has been a very profitable meeting to us all. The questions have brought out a great deal of information that Mr. Parkhurst could not give in the paper proper, for, as I remarked the first of the evening, covering all the details would require such a tremendous space.. Points thought of by the different members have been taken into consideration by Mr. Parkhurst in answering the questions.

Has any other member anything to offer?

MR. MILLER — Mr. President, I would like to ask one question before you close the subject, and that is regarding the routing or allotting of time to do each particular piece of work. I will qualify my question by stating that some little time ago my attention was called to a certain piece of work that was to be done, and the price that the various superiors said that it would cost to do the work was somewhere in the neighborhood of $1. A machine which cost about $2000 was to be employed to perform the work. Later on this same article was made at a cost of eight cents on a device that cost less than $25. Now, what I wish to ask is, under the bonus system would they consider it an advantage to the workman in the shop if he brought such a thing as that to the attention of the routing clerk or the man allotting the work.

MR. PARKHURST — One thing that we are always very careful to do is to solicit the suggestions and help of the men in the shops. In a case similar to the one you speak of, if a piece of work was routed to a certain machine, and the man in the planning department had overlooked entirely the machine expense connected with doing that job, why, I think he would be only too glad of a suggestion similar to the one you offer. But one of the points that should be taken care of in the planning department is to devise the means to do the work in the cheapest possible way, looking at it from a point of view which the ordinary foreman is not supposed to have always in his mind, to have one man who does nothing but consider those questions. Of course the expense of doing a job is not complete until the machine expense that is connected with it is

figured in also. This system contemplates the keeping of a machine record, so that at the end of the year we can tell how many hours each machine in the shop has run. Take also the depreciation on machine tools, which is greater today than it has been in years past, on account of the work they are being put to. Of course this system will tell at the end of the year to what advantage the tools in the shop have been used. Depreciation and machine expense has got necessarily to be figured out, especially where they are driving the machines the way they are today on account of the new high-speed steel, and the machine depreciation for this reason is greater per year than formerly.

MR. MILLER — The question that I wished to ask was whether under this bonus system you allow your workmen any bonus on their suggestions. You have a bonus system according to this system you have been explaining.

MR. PARKHURST — Yes, we have a bonus system.

MR. MILLER — The workman would receive a benefit for any suggestion?

MR. PARKHURST — Yes, we calculate to pay the man for any suggestions that he can offer, and give him the advantage of them in that way. Very often we have paid a man a bonus where we were taking stop-watch observations, and taking times on the work he was doing, and in that way we have been able to get a number of valuable suggestions in regard to the machine itself, more especially little particular details in regard to it which should be taken care of, and which the foreman had never reported or perhaps had forgotten. That is one of the points that is very necessary—to keep the men in line with what you are trying to do, and let them see that it is to their advantage in the end. That is the object of it.

THE PRESIDENT — Would any other member or visitor like to say something at this particular time? If not, I will ask Mr. Parkhurst if he has any remarks to make in closing.

MR. PARKHURST — What comes to my mind chiefly is that I owe to you, Mr. Leach, and also to your club, my thanks for the reception you have given me here tonight, and I thank you all.

THE PRESIDENT — Mr. Marden offered a motion for a vote

of thanks to Mr. Parkhurst, which I did not hear seconded, as he continued.

[The motion was seconded by several members.]

THE PRESIDENT — It is moved by Mr. Marden and duly seconded that this Club extend to Mr. Parkhurst a vote of thanks for the very interesting and instructive paper that he has rendered to us this evening.

[The response was a rousing "Aye."]

THE PRESIDENT — I doubt if there can be any room for a negative voice on that, and the vote is unanimous. The discussion on this subject is closed.

Is there any other business, Mr. Secretary? I have an announcement and also a thought. The thought, while it is not necessary to speak of it, is on the old-time subject of a Ladies' Night. In the Executive Committee meeting this evening it was the individual expression of opinion that a Ladies' Night was a thing to have. [Applause.] The Chairman of the Committee which has had this subject under consideration was unable to be with us this evening on account of a death in his family, but I presume that we shall hear his report later, and it may be necessary to call a special meeting of the Executive Committee to consider it. That, however, is simply a remark to the Club from the chair in an informal way, to let you know that we are giving the subject our attention, and we shall want you to give it your attention when we are ready to come to you with the tickets. It is going to be worth all we shall ask. I don't know what we shall ask of you this year, but it will be worth all we shall ask. We have a large gathering here tonight, and everyone should come and bring his family.

The announcement of the evening that I have in mind is the subject for the January meeting, which is to be a paper on the *Uses and Advantages of the Combined Automatic and Straight Air Brake Equipment*, by Mr. Blackall of the Westinghouse Air Brake Company. This will interest more particularly the railroad men, and I trust that they will all turn out, and, if they know of anyone in this particular line of business that it would interest, even though not a member, invite them to come here, as invitations have been extended tonight to friends who have helped us enjoy this meeting.

The Secretary has "put me next" to another announcement, which it should be unnecessary to make, because there is a sort of magnet over in this left-hand corner here that is noticeable as soon as they draw the door. You all know what is there. If there are any who don't know they should be taken care of by friends. Those who are in favor of passing into the room on the left after a pleasant little "How do you do" among themselves, will rise. The meeting is adjourned.

[Adjourned.]

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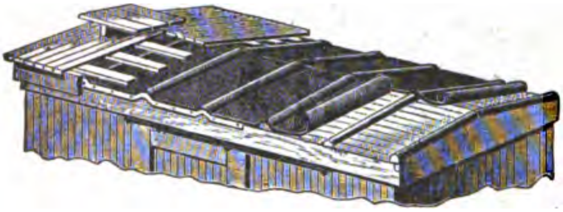

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